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## ABSTRACT

This report provides administrators, school boards, and policymakers with data to help them in the decision making process related to distance education systems. A literature review covers theories of distance education, distance education today, the economics of distance education, distance education and technology, transmission systems, and distance education classrooms. Results of a cost analysis that utilized face-to-face, telephone, and written interviews to identify costs required to design, build, and install a distance education system are presented. Costs are summarized and categorized in two sections: the first section deals with the costs of fiber, microwave, and compressed video systems; the second section deals with the interactive distance education classroom costs. Supplemental materials include: (1) flow charts of the three types of systems; (2) a table of cost comparisons; (3) a description of the Iowa Communication Network; (4) a directory of interview sources; (5) an outline of considerations for setting up a distance education system; (6) tables of detailed cost estimates for each type of system; (7) sample microwave path studies and profiles; (8) classroom designs and equipment lists; and (9) Iowa Narrowcast Advisory Committee Classroom Equipment Specifications. (Contains 114 references.) (ALF)

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# DISTANCE EDUCATION:

## A Cost Analysis

by

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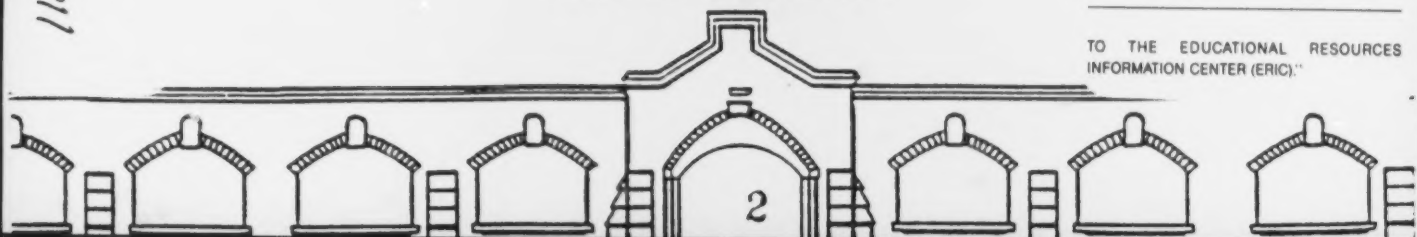
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## DISTANCE EDUCATION: A COST ANALYSIS

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### INTRODUCTION

The concept of distance education is enlarging the definitions of how students learn, where they learn, and who teaches them (U. S. Congress, 1989). In the past, distance education was of greatest importance to adults. Recently, there have been increasing numbers of distance education opportunities offered to high school students, and even elementary schools have taken advantage of enrichment activities offered to children from distant sites.

Distance education has become increasingly sophisticated since the first educational radio programs. Barker (1989a) referred to distance education as a "catch all" phrase for any form of instruction in which the learner and instructor were separated geographically and were linked by telecommunication systems that permitted live, interactive audio and/or video exchanges.

Definitions of distance education usually include Keegan's (1986) characteristics:

- quasi-permanent separation of teacher and learner,
- influence of an educational organization,
- use of technical media,
- provision of two-way communication, and
- quasi-permanent absence of group learning.

Keegan also includes the following characteristics as ones that are often part of distance education systems:

- presence of industrialized features, and
- privatization of institutional learning (p. 49-50).

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We would like to acknowledge the Office of Telecommunications and the Media Resources Center at Iowa State University for their review of the technical information in this monograph.

Distance education systems that use two-way interactive telecommunications have the following features. The instructor is at an origination site and students are at a remote site; students may be present at the origination site as well. Instruction is influenced by an educational organization—the school. Sites are connected point-to-point with fiber, microwave, or twisted pair copper media, often referred to as compressed video. This allows two-way interactive video, data, and/or audio communication and permits live interaction between instructor and students, with instruction directed to one or more students.

In this study, the term "compressed video" refers to video signals that have been digitized and significantly compressed so they can be transmitted using traditional transmission media, including twisted pair copper wire. The terms fiber and microwave refer to the media for transmitting video and data signals, and compressed video refers to a technique for modifying a video signal. Although they are not directly related, the three terms (fiber, microwave, and compressed video) are used in the study because they are commonly cited in distance education literature.

The trend in distance education in the United States is to provide distant learners with live, two-way interactive instruction. Quality distance education is dependent on interaction and participation of learners. The goal of implementing an interactive system is to make distant education situations as close to traditional instruction as possible.

The creation and future implementation of the Iowa Communications Network (ICN) has created considerable interest about distance education among Iowa school administrators. (See Appendix A for a description of the ICN.) This interest largely centers on questions regarding funding for schools utilizing the ICN, the future prospects of the ICN, and when the ICN will be completed.

Today, the technical capabilities exist for schools to provide distance education opportunities to students. While advances in technology make it possible for school districts to improve their curricula and learning experiences, the use of technology also creates

new problems. Technology is expensive and complicated, and some question the propriety of using telecommunications to offer courses to students located at remote sites.

Administrators, school boards, and policy-makers often ask about how much distance education costs. Since distance education systems require significant cost commitments, those responsible for making large capital investments must have reliable data available to them to help them in the decision making process.

First, this study compares the costs of three types of transmission technology. Two of the technologies deliver two-way, full motion video and two-way audio: (a) fiber optics and (b) microwave. The third technology, compressed video, also delivers two-way audio and two-way video, but uses a computer device to "compress" the signal.

Second, this study describes costs for equipping and installing a distance education classroom. Lists of equipment and prices are supplied.

The following research questions guided the preparation of this report.

- (1) What are the characteristics, advantages, and disadvantages of the three transmission technologies?
- (2) What does it cost to put into place a point-to-point, distance education system using fiber, microwave, and compressed video?
- (3) What are the major cost considerations for the three transmission methods?
- (4) How do the costs vary for distances of 3 miles, 10 miles, 20 miles, 30 miles, 50 miles, and 75 miles?
- (5) What are the recurring and maintenance costs for the transmission equipment?
- (6) Is it usually better to lease or purchase?
- (7) What does it cost to equip an interactive distance education classroom?
- (8) What are the recurring and maintenance costs for the classroom equipment?

Distance education is a viable way to enrich and improve the quality of the curriculum. Technology can link teachers and learners from all educational levels--elementary, high

school, and college, as well as business and community --and bring a wide variety of expertise and information to the classroom. Costs can be justified by an increase in educational opportunities (Giltrow, 1989).

## REVIEW OF LITERATURE

This review of the literature summarizes research related to distance education and key variables of this study. The information in this section is organized in the following categories: (a) a brief description of theories of distance education; (b) the impact of distance education today; (c) the economics of distance education; (d) distance education and technology; (e) transmission systems; and (f) the interactive distance education classroom.

### Theories of Distance Education

Distance education has been characterized in such a variety of ways that global or general statements about it are rarely valid. Distance has several connotations, not necessarily restricted to geographical distance (Rumble, 1986b). Distance also refers to psychological, economic, and cultural separations (Burge, Snow & Howard, 1989). Distance education has been shaped by a society's needs and resources, and politicians have seen distance systems as a means to promote particular values or to achieve social, economic, and political objectives (Daniel, 1988; Foks, 1988; Giltrow, 1989; Rumble & Harry, 1982; Zigerell, 1984).

There are two views on the concept of distance education - distinctive and parallel.

Distinctive form. Many consider distance education to be a distinctive educational form based on individualized study. Many autonomous universities teach only to students at a distance and believe that distance education is a distinct form of education (Moore, 1988; Peters, 1988).

Considerable effort has been spent trying to formalize a theory specific to distance education. Keegan (1988) grouped the theories as follows: (a) *theories of autonomy and*

*independence*; (Wedemeyer, 1981; Moore, 1988); (b) *theory of industrialization*; (Peters, 1988); and (c) *theories of interaction and communication*; (Holmberg, 1977, 1981, 1988a, 1988b; Baath, 1980; Sewart, 1988). Keegan (1980, 1986) analyzed the theories presented by Moore, Peters, and Holmberg to create the descriptive definition of distance education summarized above. It is the definition used most widely today.

**Parallel form.** A second perspective considers distance education as parallel to traditional education. Garrison (1989) asserts that distance education is not unique. The techniques appropriate for traditional education systems and distance education systems are the same. Many educators in the United States subscribe to the philosophy that distance education does not differ from conventional education in any real structural sense, but is distinctive only in the delivery system (Zigerell, 1984).

#### Distance Education Today

Applications of distance education have increased dramatically during the last five years. Fewer than ten states were promoting distance education in 1987, while today virtually all states have an interest or effort in distance education (U. S. Congress, 1989). Distance education programs exist in the majority of countries in the world. This growth is primarily due to increases in educational requirements that have coincided with the expanding capabilities and services of the telecommunications industry (Giltrow, 1989). The quality of distance learning has been recognized with increasing respect and credibility (Turnbull, 1988). Distance education has been seen as a viable and cost-effective way to meet the challenges of teacher shortages, low student enrollments, and decreased funding.

Jefferson and Moore (1990) predict that all rural schools will have distance education service by 1995. A UCLA study predicts that, by the year 2010, 50 percent of the educational instruction in the United States will be "mediated education" (cited in Pelton, 1990).

Today the movement in distance education is to

utilize live, two-way interactive instruction (Gray, 1988). Research indicates that distance students not only learn from course materials, but also from interaction with instructors (Holmberg, 1981). This real-time interactive instruction simulates a sense in students of "being there."

The success of interactive distance education classes is well documented. Studies have supported the following conclusions:

- Students involved in distance education classes have reported positive feelings about their experiences (Barker, 1989b; Catchpole, 1988; Kitchen & Kitchen, 1988; Nelson, 1985; Nelson, Cvancara & Peters, 1989; Pirrong & Lathen, 1990; U. S. Congress, 1989).
- After teaching in an interactive distance education system, faculty have had positive responses about the experience (Barker, 1989b; Bowman, 1986; Hobbs, 1990; Kitchen, 1987; Randall & Valdez, 1988; U. S. Congress, 1989).
- Student achievement in interactive distance education classes has been as good or better as that of students learning from traditional teaching methods (Batey & Cowell, 1986; Hobbs, 1990; Kabat & Friedel, 1990; Minnesota State Department of Education, 1990; Pirrong & Lathen, 1990; Randall & Valdez, 1988; U.S. Congress, 1989).

#### The Economics of Distance Education

Economic implications of using distance education methods can be generalized as follows: (a) significant costs are incurred irrespective of student numbers, (b) transmission and production costs are high for systems, (c) conventional, non-distance education system costs are recurring costs and vary according to the number of students; distance system costs can be regarded as fixed costs and amortized over the life of a course, (d) from an economic point of view, investment where student numbers are small is normally not warranted, and (e) administrative functions are more clearly differentiated from the academic functions in distance education systems; distance systems are more complex (Rumble, 1982, p. 119).

One of the most significant factors when planning a distance education system is the cost. A large portion of the expenses are start-up costs, which in effect, can be the equivalent of five years worth of teacher costs. To some, paying these costs before enrollment revenues are collected is unsettling (Giltrow, 1989), and is only acceptable if costs can be amortized over a long period of time (Perraton, 1982). Factors that affect costs of establishing a system are (a) type of technology, (b) distance and topography, (c) existing and available technology, (d) possible partnerships, (e) engineering requirements, (f) remodeling needs, and (g) lease/purchase arrangements. Operating and maintenance costs are also significant (Shobe, 1986). These costs, sometimes referred to as recurring costs and fixed costs, include service and repair, license fees, maintenance fees, and lease fees. The amount of money required to establish a system is often seriously underestimated (Rumble, 1986b). Obviously, personnel and curriculum costs to train instructors and revise materials are considerable, too.

Research results show that distance education can be cheaper per capita than conventional education (Eicher, 1987; Wagner, 1982). Rumble (1982) states, "studies show that unit costs of distance education at the higher educational level are comparable with, or less than, those in conventional campus-based universities" (p. 120). Distance education has the potential for a high degree of cost-benefit and cost-effectiveness (Holmberg, 1981; Nelson, 1985). The most costly technologies, such as those used for distance education, may not result in a high cost per student (Batey & Cowell, 1986; Hudson & Boyd, 1984).

In general, three factors influence the economics of distance education: choice of media, size or type of program, and number of students (Batey & Cowell, 1986; Rumble, 1982). Although Rumble concludes that "distance learning is not necessarily a cheap way of teaching" (p. 137), the large capital investment will pay off in cost-efficiency if there are sufficient numbers of students. Markowitz (1990) maintains that distance education programs are predominantly self-sufficient. According to the 1986 [Minnesota] Governor's Report on Education,

"among the available technologies, the only ones that can be viewed as cost-effective, both in terms of research findings and practical organizational issues, are automated drill and practice and distance learning" (Kitchen & Kitchen, 1988, p. 8).

Evidence also is available to support the conclusion that distance education is effective when effectiveness is measured by achievement, by attitudes of students and teachers, and by cost-effectiveness. Generally, the evidence has indicated that distance education "works."

#### Distance Education and Technology

Telecommunications is defined as communicating over a distance. Rapid advances in technology, deregulations of these technologies, and decreases in costs have made telecommunications attractive to schools.

Telecommunications systems are often referred to by the medium, the type of information (signal) transmitted, and the direction flow. The type of information includes audio, video, and data signals. The media for communication are usually radio waves through the air, electronic impulses over transmission lines, or light through fiber made of glass or plastic silicon. The flow is defined as one-way (simplex) or two-way (duplex).

One-way communications are usually referred to as broadcast systems and are usually "top-down" communications in which the information is transmitted by electromagnetic waves to anyone with a receiver. Signals may also be transmitted to an orbiting satellite and then broadcast to receivers on the ground. There is uniformity in the programs offered and usually no direct interaction. These one-way systems are also referred to as point-to-multi-point. Television broadcasts are examples of one-way communications.

In a two-way system, points are linked through a network and tend to encourage "bottom up" and lateral communications. They often involve live, real-time interaction between individuals at two or more places. This communication, often referred to as point-to-

point or narrowcasting, is directed to a specific audience.

Two-way interactive television (ITV) and distance education. The term ITV originally referred to instructional television, but today has become synonymous with interactive television. Today's ITV technologies allow for live, two-way communication between sites. In the ITV classroom, the students and teacher see and hear one another. ITV has been shown to be comparable to the traditional method of instruction, both in terms of teacher and student acceptance and in achievement (Hughes, 1988). The Office of Technology Assessment reported that television-based interactive instruction is the distance education format that most closely resembles the traditional classroom; this has been the format of choice for many U.S. distance education systems (U. S. Congress, 1989).

Bates (1988), Feasley (1983), and Gray (1988) state there is a clear movement away from using broadcast methods for distance learning systems. "In the 1990s, it is no longer a question of whether ITV is going to become a major factor in the delivery of education. ITV is here, and there is obvious value in its use as a delivery tool" (Moore & McLaughlin, 1992, p. 76).

### Transmission Systems

Since it is possible to discuss distance education systems from a number of perspectives, this monograph examines the costs for establishing a system by studying three forms of technology that are often used to characterize particular systems: fiber-based systems, microwave systems, and compressed video systems that use existing transmission networks. As was stated earlier, the three are not directly comparable. However, when distance educators discuss systems, they often categorize them in this manner.

#### Fiber Optic Systems

Fiber optics is one of the newest two-way, interactive technologies. The fiber, made of glass or plastic, transmits light signals instead of electrical signals. An optical fiber consists of an inner cylinder called the core, surrounded by

a cylindrical shell of glass or plastic called the cladding. The cladding layer keeps light from leaking out. An outside coating, provides protection against the elements. Light travels in straight lines, but optical fibers guide light around corners. The number of fibers is unlimited, creating virtually an unlimited capacity. Optical cables are capable of transmitting far more information than coaxial cables of the same size.

Equipment required for a fiber system. The main components of a digital fiber system are: (a) multiplexor; (b) codec; (c) optical transmitter; (d) optical receiver or photodetector; (e) fiber cable; and (f) repeaters (Figure 1).

The multiplexor converts the signal to/from an electrical signal. The codec changes the signal to digital. The optical transmitter converts the signal to an optical signal, and the receiver reconverts the optical signal. Transmitters are of two types, lasers (ILD) or light emitting diodes (LED). The receivers are either positive-intrinsic-negative (PIN) or avalanche photodiode (ADP). Generally speaking, the ADP is used for systems greater than 100 km (62 miles) and PINs are preferred for shorter distances. The repeater is a signal amplification device often used along cables to extend transmission distances. The fiber cable carries the optical signal. Single mode and graded index fiber is best suited for long distances. Since a codec is needed only for digital transmission, an analog system would eliminate need for the codec. A modulator/demodulator would replace the multiplexor unit; additional amplifiers would be necessary. Life expectancy of this equipment is 20-25 years.

#### Advantages of a fiber system.

- The large bandwidth of fiber allows audio, video, and data to be combined on one line, resulting in a lower cost per channel.
- Fiber permits full motion video transmissions.
- The low attenuation rate allows for transmissions over long distances without distortion.
- The large capacity for channels means the system can be easily expanded.

- There is maximum signal security with little possibility of tapping, eavesdropping, jamming or metal detecting.
- The small, lightweight cables are easy to handle and install.
- Fiber is unaffected by weather, corrosive liquid, or gas.
- Fiber is unaffected by electromagnetic currents, static interference, electric motors, fluorescent lights, and radiation.
- Durable fiber results in low maintenance costs.

#### Disadvantages of a fiber system.

- Systems require high start-up costs.
- Special tools and tests are needed to install the fiber.
- Repairs can be time consuming and costly.
- Light sources have limited lifetimes and associated system reliability problems.
- Expansion is expensive if no fiber exists.
- Right-of-way costs for placing cables in the ground can be costly.

Successful users of fiber systems. The following groups have reported on successful use of fiber-based systems: (a) MSET--Mid-State Educational Telecommunications Cooperative, Minnesota (Giltrow, 1989; Kitchen, 1987; Kitchen & Kitchen, 1988; Lanier, 1986); (b) SHARE-ED Oklahoma Panhandle Video Network (Barker, 1989b; Currer, 1991); (c) Mississippi 2000 (Currer, 1991); (d) Bergen County, New Jersey (Daley, 1991); (e) FOCIS--Fiber Optics Communication Instruction System, Des Moines, Iowa (Ostendorf, 1989a; Schoenenberger, W., personal communication, April 14, 1992).

Opinions about fiber systems. "It is possible to confidently claim that this [fiber optics] is one of the more important technological advances of the past 20 years" (Giltrow, 1989, p. 55). Fiber optics is increasingly being chosen as the preferred method of transmission by Minnesota schools because of the possibility of future expandability (Minnesota State Department of Education, 1990). Fiber lends itself well to two-way, interactive television because of its large channel capacity (Kitchen, 1987). The cost of fiber cable is widely expected to fall below coaxial or copper cables in the early 1990s (U.

S. Congress, 1989); it will be competitive with microwave and coaxial cable (Kitchen, 1987). The cost/performance ratio for fiber continues to improve. In the last ten years, fiber transmission has become the medium of choice in telephone applications (Szentesi, 1991). Currer (1991) reported that digital fiber gives the user the most benefit for the money spent. Barker (1989b) believes that fiber offers the best audio transmission quality, while Lanier (1986) suggests that fiber is superior to microwave, ITFS, and coaxial because of its higher image quality.

General costs for fiber systems. The Office of Technology Assessment reported that the equipment needed to connect one site to a fiber network would cost approximately \$40,000. Fiber for a 134 mile network would cost approximately \$8,955 per mile. The receiving site would need \$40,000 worth of equipment, also (U. S. Congress, 1989, p. 174).

Maintenance costs average one percent of system cost per year (National School Board Association, 1989). Other vendors feel that up to 13% of the cost of a system should be reserved for maintenance. Fiber systems require little maintenance; however, if the fiber is accidentally cut, repairs are very expensive and time consuming.

#### Microwave Systems

Microwave signals are transmitted electromagnetically through the air. Microwave is similar to standard broadcasting, except microwave systems use much higher frequencies and are point-to-point. Each tower in a microwave relay system picks up the signal sent to it, amplifies the signal, and retransmits it to the next line-of-sight tower on the way to the destination point. Prior to the development of satellite communication, microwave transmission represented the only reliable form of intercity and coast-to-coast video communication (Hart, 1986).

"Long haul" systems use a number of repeaters and cover hundreds of miles. "Short haul" systems are used where traffic loads are relatively light, or where the length of the route is short. The typical range of 5 to 15 miles is suitable for local communication between two

schools. The distance between repeaters depends upon (a) topography, (b) antenna size, (c) transmitter power, and (d) receiver sensitivity. A good rule of thumb is to consider microwave if two sites are more than one-half mile but less than 20 miles apart. A good use of a microwave system is to link two buildings in the same metropolitan area. Short haul systems are relatively simple to construct and operate, and do not require regulatory agency approval or right-of-way clearance (Ostendorf, 1989a).

#### Equipment required for a microwave system.

The main components of a microwave system are (a) tower, (b) antenna, (c) antenna feed line, (d) transmitter/receiver, (e) modulator/multiplexor, and (f) power unit (Figure 2).

#### Advantages of a microwave system.

- Microwave permits the transmission of full motion video.
- There is control over who receives the signal.
- Audio and video signals are of excellent quality.
- Numerous data and audio signals can be transmitted along with video channels.
- A properly designed system can have 99% reliability (Todd Communications, 1992).
- No right-of-ways are required.
- Maintenance costs are low.

#### Disadvantages of a microwave system.

- Systems require high start-up costs.
- Transmissions are affected by weather, especially fog, rain, and lightning.
- Atmospheric disturbances can cause fading of signals.
- Equipment can fail and power outages can occur.
- Adding channels to a system is not easy.
- Thirty miles is the maximum distance between towers.
- An FCC license is required.
- A limited number of frequencies are available.
- Towers are almost always needed.
- Terrain extremes can increase equipment and tower costs.
- Special building permits may be needed.

Successful users of microwave systems. The following groups have reported on their successful microwave systems: (a) WHETS--The Washington Higher Education Telecommunication System, Washington State University (Nelson, Cvancara & Peters, 1989; Oaks, 1986); (b) TWIT--Two-Way Instructional Television at Morning Sun, Iowa (Nelson, 1985); (c) TIE--Televised Interactive Education Eastern Iowa Community College District (Kabat & Friedel, 1990, Wallin, 1990); (d) TAGER--Texas Association for Graduate Education and Research at Dallas-Ft Worth, University of Texas at Dallas (Hart, 1986); (e) KTS--Kirkwood Telecommunications System at Kirkwood Community College, Cedar Rapids, Iowa (Hart, 1986; Hudspeth & Brey, 1986); (f) KIDS--Knowledge Interactive Distribution System, Minnesota (Descy, 1991).

General costs for microwave systems. The estimated costs for a duplex microwave system include \$40,000-\$65,000, plus towers, which range from \$25,000-\$75,000 each (Kitchen & Kitchen, 1988; U. S. Congress, 1989). Short haul systems may cost \$35,000, plus towers, which range from \$5,000-\$50,000.

Maintenance costs average three to five percent of the system cost per year (Kitchen & Kitchen, 1988; National School Board Association, 1989; U.S. Congress, 1989). These costs include equipment service and repair and monthly maintenance fees.

#### Compressed Video Systems

Compressed video is a name routinely, and somewhat incorrectly, used to refer to digital video, audio, and data signals that are processed to reduce the amount of information in order to minimize the bandwidth required. It is important to note that compressed video refers to a technique for reducing the amount of information transmitted between two sites. A "compressed" signal can be carried by fiber or microwave, but since it has been compressed, traditional, inexpensive, and readily available copper wires can also be used. In other words, the installation of a compressed video system is often simplified because existing communications carriers can be used.

Compressed video is sent over fiber, satellite,

microwave, and most often, high capacity digital service lines. In compressed video transmissions, redundant information is removed. For example, if the background does not change for several seconds, this information is sent only once and remains in memory. Video compression is achieved by sacrificing small amounts of color, motion, or resolution information. Although there is some loss of quality, compressed video is considered a viable alternative for many educational situations.

Equipment required for a compressed video system. Each system site must have (a) codec; (b) transmission line; and (c) interface unit (Figure 3). The codec converts the analog signal to digital format and compresses the signal. The channel service unit (CSU) is the interface between the end user and the telephone line. The CSU works in conjunction with the data service unit (DSU), which translates and controls the signal. This unit functions similarly to a modem (modulator/demodulator).

T channels refer to a band of high speed, high capacity circuits devised to carry digital voice, audio, and data signals. These digital, full duplex transmission facilities (T1, T2, T3) are classified by the megabits per second (Mb/s) they transmit. A T1 facility transmits up to 1.544 Mb/s; the T3 facility transmits up to 45 Mb/s (equivalent of 28 T1 channels). Signals carried on T facilities are classified by the digital signal level or pulse code modulation line rate (DS1, DS2, DS3). A DS1 signal level has a transmission format in which 24 telephone voice channels can be multiplexed into one T1 channel. T1 facilities and DS1 signals are the technology most often used for compressed video systems. DS1 signals have bandwidth capability for compressed video only; they do not have the necessary bandwidth for full motion video as does DS3. T1 facilities are often regular copper telephone lines. T1 transmission lines can be leased from telephone companies.

Frame speed. Compressed video is available at 30 frames per second at 384 kb/s and 1.544 Mb/s. The P x 64 standard of 30 frames per second is not the same 30 frames per second of full motion video. The P x 64 standard rates pixels per

screen, while the National Television Standards Committee (NTSC) video signal does not have pixels. The P x 64 thirty frames per second means the picture is refreshed or updated every 30 seconds. Differences in picture quality can exist within this standard. Different vendors' codecs refresh different elements such as color, gray scale, or motion.

#### Advantages of a compressed video system.

- The equipment is easy to install and use and little training is required.
- Compressed video requires less bandwidth and therefore it costs less to transmit.
- Compressed video can have a price advantage over fiber or microwave in long distance installations or systems in hostile terrain.
- Compressed video interfaces with existing systems and is easily upgradable (Todd Communications, 1992).

#### Disadvantages of a compressed video system.

- Systems have high start-up costs.
- Motion can become jerky.
- Color may be substandard and picture quality may be poor.
- There is dependence upon the lease-lines of the utility supplier.
- Compressed video systems do not transmit NTSC, full motion video.

#### Successful users of compressed video systems.

The following groups have reported successful use of compressed video systems: (a) California State University Campus, Bakersfield (Ward, 1990); (b) V.E.I.N.--Video Education Interactive Network, Wyoming Center for Teaching and Learning at Laramie (Edwin, Owens & Rezabek, 1991); (c) Penn State (Phillips, 1987); (d) IVN--Interactive Video Network, North Dakota (Tykwinski & Poulin, 1991); (e) University of Minnesota (Kolomeychuk & Peltz, 1991).

#### Research relating to compressed video systems.

The Applied Research Institute (cited in Keller, Staab & Stowe, 1989) found that (a) compression technologies have improved, (b) at the same time that signals have been further compressed and equipment costs have dropped, picture quality has remained relatively good,

(c) compression devices can now digitize and blend (multiplex) signals so different kinds of information can be sent simultaneously, (d) the hardware and software are still expensive even though prices have decreased, (e) standards are emerging for compatibility among vendors, and (f) use of existing transmission lines make compressed video cost-effective.

A study conducted in Japan reported that compressed video had practical use for teaching at a distance in an interactive environment (Wakamatsu & Obi, 1990). Jurasek (1992) conducted a study of the effectiveness of Iowa State University classes taught using compressed video technology. Students displayed positive attitudes toward instruction. They adjusted rapidly to the compressed video technique and felt the convenience of learning remotely far outweighed the effects of any picture quality loss or technical problems.

General costs for a compressed video system. Compressed video systems range in cost from \$20,000-\$300,000 (Ostendorf, 1989a). A typical point-to-point system would cost approximately \$100,000. For example, in North Dakota, the implementation costs for compressed video digital systems averaged \$29,502 per school in comparison to analog fiber systems that averaged \$60,706 per school (Hobbs, 1990).

#### Distance Education Classrooms

Classrooms for ITV are usually one of two types. The first type is a production studio, comparable to a television studio. Production studios require special lighting, a control room, and a crew. The second type of distance education facility is the electronic classroom. In this classroom, there is no control room; the technology is operated by the instructor. The classroom is both a television studio and a learning environment. The concept is to make the technology as transparent as possible and to make the teaching site appear to be a classroom, not a studio.

#### Characteristics

Various examples of distance education

classrooms are discussed in the literature. The following are characteristics that are described as important considerations for planning for the installation of a distance education classroom.

Size. The classroom can be a conventional school room, which typically is about 25 feet x 35 feet. Converted classrooms can be used as long as acoustic, lighting, and other needs are met (Hudspeth & Brey, 1986). Hughes (1988) stated that a distance education classroom should be longer than it is wide.

Soundproofing. Soundproofing may be necessary to exclude exterior noise and to reduce classroom noise. Since sound can enter anywhere air can enter, all holes and gaps in or between walls, floors, and overhead structures should be filled and sealed. Doors should be of solid construction and equipped with floor sweeps and weather stripping (Price, 1991). Windows should be double pane, if possible. Walls, floors, and ceilings should be sound resistant and constructed of dense materials such as concrete, solid masonry, or double layers of gypsum board (Hudspeth & Brey, 1986; Price, 1991).

Interior noise is generated by ventilation systems, fluorescent lights, television monitors, furniture, and other equipment. Ventilation systems should be run constantly at a low pressure, if possible. Systems that cycle on and off are very distracting and may require users to make constant audio adjustments. One way to test a potential distance education room for external and internal sound disturbances is to tape record the room when it is not in use. This tape will indicate outside noise disturbances and distractions from such things as ventilation and lights within the room.

Decor. Esthetic considerations for the classroom are fairly subjective. There are, however, particular items that do affect quality. Background color is particularly important for two-way video systems; there should be no complex patterns. All surface finishes should be non-glare. Materials such as chrome, glass, and shiny plastics create distracting glare that can be reflected onto monitor screens.

Lighting. Television is best viewed in normal light or in a slightly dimmed room. Natural

light from windows and skylights is usually too bright for television monitors and can cause glare on screens. This can be controlled by draping or facing the monitors away from windows. However, television cameras require light to capture images and usually normal room lighting is adequate. For most purposes, common fluorescent light fixtures provide adequate and economical lighting. In the typical classroom, no special lighting is needed (Ostendorf, 1989a).

**Classroom arrangement.** Two-way video classrooms have few possible arrangements. Participants must be seated in relation to cameras and microphones, thus limiting the configuration of the room and the size of groups. Students should be seated so they can see each other and not have to turn to face the camera. Monitors should be placed in the front and possibly rear of the room so participants and instructors can maintain continuous visual contact (Fink & Tsujimura, 1991).

It is best to avoid placing monitors in a corner; this can diminish the importance of the material being presented and can create awkward viewing angles (Price, 1991). A viewer should not have to look up at an angle greater than 30 degrees (Price, 1991; Wood & Wylie, 1977). Looking upwards at a sharp angle for long periods can be tiring and uncomfortable. Monitors should be ceiling or wall mounted, four to six feet off the floor, if possible (Wood & Wylie, 1977). Remote site monitors should simulate the eye level of the instructor.

There should be comfortable seating for students and teacher (Minnesota State Department of Education, 1988). Individual comfort and appropriate style should be the highest priority. For extensive note taking or working with materials, learners should be provided with 20-24 inch wide tables.

Optimum class size is 15 to 25 students (Barker, 1989b; Bowman, 1986). By keeping classes small, students will interact more readily and use the system more fully (Lanier, 1986).

**Teacher station.** An important element of the system is the teacher station. There are various forms--table, desk, lectern, or special

built podium. The teacher station always faces student seating. Putting this station on a riser increases visibility (Minnesota State Department of Education, 1990).

It is desirable for the teacher to have full control of cameras, lights, monitors, and various auxiliary equipment. If the instructor controls equipment, there is no need for extra technical personnel. This promotes an instructional format like the traditional classroom; therefore, teachers do not need to completely change teaching strategies (Curren, 1991; Greenwood & McDevitt, 1987; Minnesota State Department of Education, 1990).

**Equipment.** There should be standardization of equipment and installation, so in case of breakdowns, spare parts or items are interchangeable. Identical equipment makes it possible to verbally instruct someone on how to adjust equipment at remote sites, and with identical equipment, either site can serve as the origination site (Minnesota State Department of Education, 1988; Randall & Valdez, 1988).

- **Microphones.** Sound quality is the most problematic aspect of distance education systems; it is the most often reported technical complaint (Bowman, 1986; Descy, 1991; Fink & Tsujimura, 1991; Hobbs, 1990; Price, 1991). Each component of the audio system should be of highest quality (Ostendorf, 1989b; Price, 1991). Directional or cardioid microphones are best.

Two problems commonly occur in sound systems, feedback and echo. Feedback is caused when microphones pick up sound from the speakers, producing overamplification and a piercing squeal from the speaker. Any time open microphones and open speakers are in the same room, feedback is a potential problem. This can be alleviated by separating the microphones and speakers.

Echoes in the room are caused by sound reflections off smooth surfaces such as hard walls, floors, and ceilings. The shape of the room, the floor, ceiling, and walls all affect reflection. An

acoustically treated room will not have echoes. To reduce echoes, acoustical ceiling tile and wall covering should be considered. Carpet is the best and least expensive sound absorber to improve acoustics in distance education classrooms (Hughes, 1988; Minnesota State Department of Education, 1988; Price, 1991). Television does not add to acoustical difficulties already existing in a room, but it does make them more acute. Acoustical problems in the class can negatively impact on learning (Smith, 1961).

- Cameras. Most interactive classrooms have three cameras. One is pointed at the students, the second at the teacher, and the third is at the desk or above the instructor, focused on graphic materials (Barker, 1989b; Bowman, 1986; Currer, 1991; Lanier, 1986; Minnesota State Department of Education, 1990; Nelson, Cvancara & Peters, 1989; Oaks, 1986). Some classroom systems have a fourth camera pointed at students (Fink & Tsujimura, 1991).

Remote zoom and auto focus controls for cameras are recommended (Hughes, 1988; Minnesota State Department of Education, 1988; Oaks, 1986). Remote tilting and panning can also be added as extra features.

- Monitors. Monitors let the instructor and origination site students view students at the remote site. Monitors also let the instructor view what is being transmitted. Monitors at the remote site show what is being transmitted from the origination site.

Most systems use 21-25 inch monitors (Barker, 1989b; Minnesota State Department of Education, 1988; Smith, 1961). Others use large screen projectors (Fink & Tsujimura, 1991; Greenwood & McDevitt, 1987). Some systems use a split screen to present the view from two cameras. Hughes (1988) reported that the split screen makes remote sites even smaller and seemingly more remote. He suggested using an additional 25 inch

monitor rather than splitting the screen.

- Visual presenter. This device functions like an overhead projector. It is located at the teacher station, normally to the right of the instructor. A color camera in the device projects photographs, charts, maps, and three dimensional objects. The camera has the ability to zoom in on the platform where materials are placed and functions similarly to the overhead camera.
- Telephone. A telephone provides for alternative communication in case of emergency or equipment failure and allows for a direct link to the remote site (Minnesota State Department of Education, 1988; Randall & Valdez, 1988). It also allows for student/teacher one-on-one, semiprivate/private conversations.
- Facsimile machine. A facsimile transmits printed copy from classroom to classroom quickly. It can be used to supply immediate feedback for tests and corrected assignments (Descy, 1991; Minnesota State Department of Education, 1988). A facsimile may not be necessary if there is a dependable delivery service or a traveling teacher or administrator.
- Videocassette recorder (VCR). The VCR is used to record class sessions. This recording can be used by the student who has been absent, as a backup in case of technical difficulty, to provide a record of distracting student behavior, or so that the instructor can review for self-critique (Minnesota State Department of Education, 1988; Randall & Valdez, 1988). Special class sessions can be recorded for use in the future, also.
- Auxiliary equipment. In-class presentations may require the use of a videodisk player, a videocassette player, a tape recorder, or a record player. This equipment can be located in the room on a cart and plugged into the system as an auxiliary input. Films and slides may also be shown as an in-class presentation by projecting the film or slides onto a projection screen and focusing either the teacher, student, or visual presenter

camera on the screen. If there are many slide and film presentations planned, slide/film to video converters should be purchased.

- **Computers.** Use of computers as an auxiliary input requires special equipment. Computer monitors have different resolution capabilities and different scan rates than television monitors. Special equipment is needed to interface the two types of video. Output from high resolution computers must be converted down to the NTSC video standard, or multiscan monitors must be used.

### METHODOLOGY

This cost analysis identified costs required to design, build, and install a distance education system using fiber, microwave, and compressed video. Cost analysis was defined by Perraton (1982) as the process used to discover all the costs involved in a particular activity. Adams, Hankins, and Schroeder (1978) defined cost analysis as any manipulation of cost data that provides relevant information for those who make decisions. A common method is simply "a direct comparison method between or among the costs of specific decision alternatives, e.g., a make or buy decision" (p. 24).

#### Data Collection

Data were collected using face-to-face, telephone, and written interviews. Questions were designed to determine the total costs for establishing a distance education system. Interviews were open-ended to offer flexibility and opportunity to pursue additional information. Reliability was built into the interview process by the use of repeated questions, rephrased questions, and follow-up questions. Also, interview questions were asked of more than one source.

#### Procedures

The first activity of this project was to obtain general information from the literature,

consultants, telecommunications specialists, governmental offices (federal and state), and vendors. Next, specific questions were prepared. These questions were designed to identify hardware components essential to transmit and receive audio and video signals between two sites.

Technical experts who had experience with the transmission systems provided valid cost information. Also identified were vendors and consultants who had experience with distance education classroom equipment (Appendix B).

Six hypothetical pairs of sites of varying distances from one another were chosen. Vendors were identified to provide estimates about costs about transmission media.

For the classroom equipment phase of this study, technical experts aided in the identification of designs, equipment items, and installation procedures. This process resulted in a classroom design and equipment list. Vendor catalogs and vendor quotations were used to obtain equipment prices.

### RESULTS

Costs are summarized and categorized in two sections. The first section deals with the costs of fiber, microwave, and compressed video systems. The second section deals with the interactive distance education classroom costs.

#### Costs of Fiber, Microwave, and Compressed Video Systems

When setting up a distance education transmission system, specific elements define costs for each technology. These elements usually fall into three areas--feasibility and planning, system design, and purchase and installation (Appendix C).

#### Fiber Systems

Fiber optic systems consist of cables that transmit light signals rather than electrical signals. Purchasing and installing fiber systems is a complex process. Nearly 95 percent of the

interactive television systems designed today use fiber optics in combination with coaxial cables.

Fiber systems can be analog or digital. While the fiber is identical, the termination equipment is different. Digital fiber provides higher quality at a distance. Analog is more appropriate for short distances. Analog fiber picks up noise over distances; digital fiber does not. An analog system is cost-effective for distances under 30 miles, but the costs for an analog fiber system over 30 miles may be prohibitive since a repeater (booster) is needed every 30 miles (at a cost of \$15,000-\$18,000). A building protecting each repeater is also required (at a cost of \$1,500).

What does it cost to put into place a point-to-point fiber system? The total cost of a fiber system depends on the fiber type, total system design, and location. T. Crandall, General Services, indicated that fiber for state of Iowa projects cost approximately \$12,000 per mile, based on 10 miles (personal communication, June 4, 1992). H. Sarrazin, Tele-Systems, concurred that fiber costs \$10,000-\$15,000 per mile (personal communication, May 21, 1992), and W. Fackler, Spectra Associates, generalized costs of fiber at \$15,000-\$20,000 per mile (personal communication, May 29, 1992). D. Takkunen, Todd Communications, estimated fiber costs at \$20,000 per mile (personal communication, April 27, 1992). All of these estimates were strictly for labor and fiber; equipment and right-of-way expenses have not been included in the totals above. In metropolitan areas such as Des Moines and Cedar Rapids, Iowa, where there are right-of-way expenses and higher costs for labor, installation rates may be as high as \$70,000 per mile.

One vendor supplied budgetary cost data for fiber systems at approximately \$18,000-\$22,000 per mile (Appendix D). T. Crandall, General Services, stated Iowa schools would likely pay somewhere between \$12,000 and the \$22,000 per mile (personal communication June 4, 1992).

#### What are the major cost considerations?

- Consultation. Charges for consultants vary greatly, with costs dependent upon detail,

distance, and location. Services include (a) feasibility studies, (b) route surveys, (c) coordinate specifications, (d) right-of-way checks, (e) and route designs with drawings. In a route design, the entire distance is mapped. In a city, the map would be more detailed and would show underground cables, gas lines, and electric cables. Also included in some consultation fees are costs for staking the route, supervising the construction, and crew scheduling.

Consulting services average \$5,000-\$15,000 (D. Takkunen, Todd Communication, personal communication, April 27, 1992). At MWR, consulting costs are charged at the engineering rate of \$50 per hour (B. Norgaard, personal communication, June 9, 1992). In an MWR cost study, consulting costs range from \$3,000-\$3,500 for rural areas to \$7,500 for urban areas (Appendix D).

- Construction/materials. Labor construction costs ranged from \$0.97 per foot to \$1.55 per foot depending upon distance. Construction costs differ between rural and urban locations. Urban areas require more field work, engineer work, concrete work, and easement attainment. The costs listed in Appendix D are for suburban locations with various open areas, not downtown metropolitan areas. A downtown urban area requires additional concrete work costing \$10 per foot or more.

Material costs are estimated to be \$9,672 for rural construction and \$15,712 per mile for urban construction. Material costs include fiber, manholes, warning tape, warning signs, and splices. In urban areas, duct costs are also added, and additional splicing and manhole costs are required.

- Easements. If construction crosses roadways or railroads, an application usually must be filed to obtain an easement right-of-way. Most easements are obtained as public right-of-ways by formal application to the city, county, or state entity. If a public easement is obtained, a license is needed to place the cable in this right-of-way. Cities often charge approximately

\$1 per foot per year for easements. Other entities typically charge a percent of revenues for easements. When crossing private land, it may be necessary to pay for easement rights to the private individual.

- **Terminal equipment.** Digital end point equipment varies in price according to speed of transmission and capacity. Digital end equipment is usually one unit that functions as the codec, laser transmitter, optical receiver, and multiplexor/demultiplexor (MUX/DEMUX). Equipment cost estimates range from \$25,000-\$57,000, including installation, for one site. Digital terminal equipment, connectors, and installation of this equipment costs approximately \$70,000 for two sites (T. Crandall, General Services, personal communication, June 4, 1992). Analog end point equipment costs \$6,000. Costs for leasing fiber usually include the costs for all equipment except for the device that converts the video signals generated in the distance education classroom into signals that can be transmitted through the fiber. This device costs approximately \$6000 - \$8000.

### Microwave Systems

Microwave signals are transmitted through the air electromagnetically. Microwaves can carry full motion video. The placement of towers, equipment configurations, federal regulations, and frequency specifications necessitate technical assistance and custom-made bids.

For a short distance, point-to-point system between two schools, microwave would be an appropriate choice. Microwave systems are easy to install, especially if transmitters are placed on buildings (Burt, Electronic Engineering; Fackler, Spectra Associates, personal communication).

Microwave signals can be analog or digital. Analog is less expensive since equipment is not needed to create digital signals. Digital costs are decreasing, but many organizations continue to utilize analog systems (D. Takkunen, Todd Communications, personal communication, April 27, 1992). Many companies only install

new analog microwave systems to be compatible with previously constructed analog systems. When constructing an entirely new system, digital microwave is generally used because it provides higher quality. Analog is affected by weather and atmospheric conditions that can cause fading, which produces noise and creates a hiss on the line.

### What does it cost to install a microwave system?

The average cost to construct a microwave system covering a short distance is \$40,000. Long-haul, one-hop systems over 8-15 miles can cost \$150,000-\$250,000. The use of repeater towers adds expenses for additional electronics, path studies, installation costs, and tower costs. Each repeater tower adds approximately \$90,000 in equipment costs and \$20,000-\$35,000 in tower construction costs (Appendix E).

### What are major cost considerations?

- **Consultation.** Services include (a) path profile to check for obstructions (Appendix F); (b) frequency coordinates to find other frequencies that might interfere; (c) path analysis to determine how much power is required (Appendix F); (d) completion of the FCC application; and (e) tower specifications to note items such as ice and wind load.

Consulting services cost \$2,000-\$4,000, with an additional \$2,000 for tower specifications (Todd Communications). A one-hop path profile/coordination usually costs about \$1,500.

- **Tower construction.** Besides distance, tower height is dependent upon obstructions, elevation above sea level, and earth curvature. To transmit 20 miles, the antenna must be at least 150-200 feet on both ends. The 200-foot tower is average in Iowa. Towers over farm land can be fairly short, but any trees, buildings, or grain elevators in the path will increase the height requirement.

A 20-foot tower is the minimum height for a transmitter. In order to clear trees, a 50-60-foot height is normally required. To

place a dish on a building, the building must be high enough to clear trees and obstructions. Antenna extensions attach to a wall and extend beyond the building roof. A 20-foot tower in Iowa is generally a building or side-mount type and would cost approximately \$5,000 (D. Takkunen, Todd Communications, personal communication, April 27, 1992). An antenna on top of a two-story school building can send signals only a short distance.

A 100-foot tower costs approximately \$20,000. A 200-foot tower costs approximately \$30,000 and a 300-foot tower costs approximately \$35,000. Construction costs are higher for self-supporting towers, but less land is required since no guy wires are needed. A 200-foot, self-supporting tower costs approximately \$200,000. A short, light weight tower for a short distance transmissions may cost as little as \$2,000-\$3,000. A heavier tower that attaches to the side of a building and extends up to 100 feet will cost about \$5,000.

- Land. Land is needed for the tower site. A 200-foot tower requires two acres of land. It is sometimes desirable to lease land if possible. A land lease will usually cost \$500-\$800 a year in rural areas and as high as \$5,000-\$6,000 per year in urban areas.
- Equipment. The following equipment is needed at both ends of the system--transmitters, receivers, antennas, hardware connections. This equipment costs on average \$45,000 at each end for long haul systems and \$11,000 per end for short haul distances.
- Building. It is often necessary to construct a building to house the electronics at each tower site. Building construction is approximately \$1,500.
- Connections to the school. The tower should be located within a mile of the school. If towers can not be located near the school, short haul systems are required to get from the tower to the school.

Coaxial cable used to connect the tower to the school costs about \$5,000-\$6,000 per mile, and an amplifier is needed every 2,000 feet (\$500 each). At the school, the cable is hooked to a translator channel box for television reception, or to a VCR connection.

- Installation and testing. Before buying a microwave system, it is advantageous to place equipment on trucks and transmit from the point-to-point locations to verify that there is no interference. Installation and testing of equipment and systems cost up to \$15,000-\$30,000 per tower location.
- FCC application. A completed FCC application form #402 is required. The application fee is \$155. Multiple hops require more than one license. Noncommercial educational broadcasts are exempt from charges (Code of Federal Regulations, 1991, §1.1112 (c)). A letter to the FCC would be necessary to request a fee exemption. The FCC requires that frequency coordinations must be completed by microwave technical experts, at a cost of approximately \$1,000 to \$1,500.
- Long and short haul systems. The maximum distance between towers is about 30 miles. Any distance over 30 miles would require repeater towers to boost and retransmit signals. Distances closer to the 30 mile limit require higher towers, more powerful transmitters, and larger antennas. Each repeater tower needs two sets of equipment, pointed each direction and adds approximately \$100,000 to the cost of the system, plus additional installation and testing costs. Short haul systems can be purchased for as little as \$15,000 to \$20,000.

#### Compressed Video Systems

As used here, compressed refers to digital video, audio, and data signals that are processed to reduce the amount of information required for transmission. This process reduces the bandwidth requirement. Compressed signals can be sent using any transmission method. Compressed video systems do not

transmit full motion video, but do allow users to economically transmit signals on smaller bandwidths.

#### What does a compressed video system cost?

Equipment is needed to compress signals and change signals from analog to digital. This equipment costs approximately \$36,000-\$38,000 per site.

- **Consultation.** These services are often included in the total cost of vendor's packages. Design coordinators provide input about the equipment needed for particular classrooms.
- **Equipment.** Transmission equipment consists of a codec, interface, and a leased transmission line. Codecs average \$36,000 (Appendix G). A CSU/DSU interface costs approximately \$1,700. Transmission line lease rates vary from \$5,000-\$20,000 a year, depending on the vendor and the distance.
- **Installation.** Charges for installing codec equipment are often included in the codec's purchase price, but some vendors charge as much as \$1,500 for this service.
- **Upgrades.** Most vendors now have codecs that can be upgraded by updating their software. This is an essential because this technology is changing so rapidly. These upgrades cost \$8,000-\$15,000.
- **Transmission line lease options.** When leasing services, there is normally a one time connection charge of approximately \$1,400; this charge is not related to distance. Lease rates vary considerably. The longer the distance, the less per mile per month. Year lease rates range from \$5,000-\$20,000 for distances of 3 to 75 miles. Most schools apply for and receive FCC-1 tariff rates. If the origination and receive sites are not in the same Local Access Transport Area (LATA), contacts must be made with the local carrier who will then make arrangements with the distant site's carrier.

It is possible to lease terminal equipment

(codecs). The list cost is multiplied by a cost factor to arrive at the monthly charge. A \$36,000 codec leases for \$1,136 per month, or \$13,632 a year, based on a 36-month contract. Shorter contracts cost more per month. For a 12-month lease, the monthly charge averages \$2,800 (or \$33,600 per year).

#### Other Results

##### How do the costs vary for distances from 3 miles to 75 miles (Table 1)?

Transmission using fiber and microwave are directly affected by distance. Fiber is affected the most dramatically. The costs per mile are very high and each additional mile can add \$12,000-\$20,000 to the cost of a system.

Microwave costs are also affected by distance. The longer the distance, the higher the tower, and the larger the antenna dish needed. A 6-foot dish is \$1,500, compared to a 12-foot dish which costs approximately \$6,000. Every increment of 20-30 miles requires a new repeater tower with two sets of electronics. Each repeater tower can add \$90,000-\$120,000 for equipment, \$20,000-\$35,000 for tower construction, and approximately \$25,000 for installation and testing. Path studies for each additional hop cost \$1,000-\$1,500.

Compressed video systems are the least affected by distance. Most of the cost of a system is in the codec equipment at the end points. Compressed video systems are fairly constant in cost.

##### What are the recurring and maintenance costs?

Transmission equipment is usually quite reliable. However, service and maintenance are important considerations for these systems. Technology does not always work and environmental circumstances may necessitate costly repairs. Maintenance contracts should state how readily the vendor is expected to provide service.

**Fiber.** Fiber equipment is reliable and needs few repairs. Replacement of a laser may cost \$2,000 to \$4,000, but laser failure is not common.

Maintenance contracts for end point equipment are about one to two percent of the purchase price. This amount averages \$3,300-\$7,600 per year.

**Microwave.** Circumstances that require maintenance on microwave systems are wind damage, ice load, electrical storms, and electronic equipment failure. Maintenance contracts vary, and range between one to ten percent of the system's purchase price.

**Compressed video.** Maintenance contracts range from three to seven percent of the purchase cost. A recurring expense is the lease cost of the transmission line.

What are the characteristics, advantages, and disadvantages of the three transmission technologies?

**Fiber.** Fiber is superior in signal quality and bandwidth capacities. Fiber is unaffected by the environment and needs little maintenance. Fiber costs per channel capacity are cost-effective. The disadvantages of fiber are high initial cost and the complexity of installation.

**Microwave.** Microwave transmission for short distances is cost-effective. Short distances use inexpensive towers and relatively low cost transmission equipment.

One disadvantage of microwave is that it is an aging technology, and the majority of frequencies in metropolitan areas have been assigned. Distance education systems require a great deal of channel capacity. In the last five years, the increasing use of cellular phones has decreased the number of available frequencies. For short haul microwave systems (which utilize higher frequencies), there are more frequencies available.

In certain areas, microwave may not be feasible because of the terrain. Microwaves are affected by weather conditions, and some find FCC licensing and adherence to regulations restrictive.

**Compressed video.** Compressed video is easy to install and is relatively inexpensive as compared to the other systems. For educational purposes, compressed video may technically not

be the best, but it is the easiest and often the least expensive to install. Since compressed video does not transmit full motion, images appear jerky at times. However, research data indicate that for most distance education applications, the quality is quite acceptable.

Leasing or purchasing?

For short term uses, leasing is often an attractive alternative to purchasing (Table 1). Leasing telecommunications systems is somewhat like leasing a car. Maintenance and operation are the responsibility of the lessor. The lessee is only concerned with using the system. However, owning one's own system has advantages, too, including cost advantages.

Distance Education Classroom Costs

This section presents the costs for an interactive distance education classroom. Technical experts were interviewed about classroom design, production equipment requirements, types, and specifications.

What does it cost to equip a distance education interactive classroom?

The Narrowcast Advisory Committee and the Iowa Public Broadcasting Board have developed and approved a list of minimum equipment requirements for distance education classrooms (Appendix I). The total cost for one site was estimated at \$28,360. Equipment for the classroom designed for this monograph cost \$39,539 for the state-of-the-art classroom, and \$21,988 for a basic classroom (Appendix H). The Appendixes also include equipment specifications and cost estimates.

**Consulting.** Private design consultants charge approximately \$5,000 to develop a plan for a complete system. The Media Resources Center at Iowa State University charges \$250 for an initial visit and \$250 a day plus expenses for additional visits. Installation assistance costs are \$30 per hour per person. Consultation costs for installing a complete classroom would average about \$4,000.

Most classrooms are easily adapted for use as distance education classrooms. A room is

adequate if there is sufficient lighting for the cameras, no extensive glare problems, adequate wiring, and adequate space. Although most rooms have adequate wiring for distance education equipment, it is necessary to determine the power requirements for all equipment. Technicians can then verify that there are sufficient outlets and amperage levels. General rules to follow include (a) unless it is a special circuit, do not put more than five items to a line, and (b) isolate computers on separate lines.

An acoustically treated room prevents many problems associated with audio systems. Acoustic treatment includes fiber ceiling tiles, carpet, drapes, or fabric covered panels. A room can be acoustically treated for \$3,000-\$4,000.

Most classroom production equipment is reliable and does not require repair, but replacement costs for broken microphones or cameras may be needed.

**Classroom Design.** Examples of distance education classrooms are found in Appendix H. The key to the design is the equipment list. Costs reflect current catalog list prices. School systems can expect a 30 percent discount from vendors.

**Equipment Descriptions.** The size of the representative classroom in the design is 28 feet by 30 feet and will accommodate at least 24 students. Tables are 24 inches x 96 inches, each seating four students. Two monitors and two microphones are located on each table. The instructor desk can be placed upon a riser to improve visibility.

- **Cameras.** CCD cameras (charged coupled device) use a "chip" in the pick-up device rather than a conventional tube. The chip is more durable and requires less light. Included in the camera list price are a pan/tilt controller, a zoom lens, and AC adapters. The pan/tilt controller and zoom lens can be eliminated from the cameras pointed at students, but are necessary on the instructor camera. A 2-chip camera produces a higher quality signal in lower light. However, a 1-chip camera is acceptable for most

applications. Three-chip, studio quality cameras can be used, but are more expensive.

The visual presenter (document camera) features a single chip, CCD color camera with manual focus and zoom control. An overhead camera can be ceiling mounted as a substitute for the presenter. However, the visual presenter is easier to install and use.

- **Monitors.** Twenty-five inch or larger color monitors should be used at the origination and remote sites to display program output. At the origination site, a monitor should also display the remote students. Three 7 inch color monitors are used at the teacher station. One monitor displays the remote site students, one the program output, and one continually shows the document camera's output so the instructor can align materials before sending the signal from this device. The 13 inch color monitors on student tables allow for display of the program video. Individual student monitors are recommended because (a) larger projection screens lose resolution and have a degraded image, (b) the closer the distance, the better the visibility and legibility, and (c) if one monitor of the system malfunctions others are available. At the remote site, an additional monitor is sometimes added in a teacher's or principal's office for supervisory purposes.

Multiscan monitors automatically accept inputs from any video or personal computer source. If there is a need to transmit computer data, then monitors must be multiscan unless special converters are used.

- **Audio systems.** Although the ideal distance education classroom would have a microphone for each person, two people per microphone is adequate. The best microphones for the distance education classroom are cardioid. Cardioid microphones pick up sounds better from the front than the back. Cardioid microphones are used where ambient noise should be suppressed.

Student microphones should be low profile, wired, and voice activated. Low profile microphones require minimal installation. The teacher microphone should be a wireless or wired lapel-type.

Push-to-talk microphones are not recommended. They require an action on the part of the student and are not "user friendly." The clicking of the button is also a noise in the system. Frequent repairs are need when this type of microphone is used.

- Media controller. A switcher lets the instructor select and control multiple video outputs, and a remote control manipulates cameras. In a state-of-the-art classroom, a room controller functions as a switcher, controls the local and remote sites, and controls camera functions. It can also have diagnostic functions.
- Rack mount. The rack mount shelving unit fits under or beside the desk. Adapter kits need to be added to shelve individual units (\$30-\$150 each unit).
- Video distribution. A video distribution amplifier is needed if many monitors are used. This unit divides and amplifies video signals.

### SUMMARY

This study determined the costs for creating an interactive, two-way distance education system using fiber, microwave, and compressed video. Transmission costs were compared for various distances. The study also described costs for equipping and installing a distance education classroom.

Each medium was found to be unique. When selecting a medium, some compromises may be required; budget constraints or environmental factors may force trade-offs. Significant elements to consider are the content of material communicated, the quality of transmission desired, the cost, and the ease of system use.

Fiber systems were found to be more complex than the other media. Microwave and

compressed video systems had elements that were comparable from system to system. It was most difficult to estimate costs for fiber systems. There are more cost variables to consider, and these variables are not consistent between applications.

If full motion video is necessary, microwave systems are viable alternatives for schools. Microwave systems are cost-effective and easy to install if the transmission distance is less than 10 miles. Microwave is also the least expensive option for short distances. Leasing microwave towers can decrease costs for two-hop systems, but leasing still requires a large investment.

Microwave transmissions can be affected by weather conditions. Adverse weather can also inflict damage on microwave equipment. Microwave frequencies are not always available, and geographic topography may limit microwave feasibility.

Compressed video systems offer the quickest and easiest solution for creating an ITV network between two schools. A compressed video system can be installed with little need for extensive construction. Most educators say they prefer a full motion system, but research indicates that compressed video is effective and satisfactory and that the picture quality of the compressed video technology is constantly improving. Most viewers do not object to small sacrifices of color, motion, or resolution. Successful users indicate that content takes precedence over image quality.

Concerning the three transmission systems, it was found that:

- Fiber was found to be most expensive and fiber systems were more complex than other media.
- Microwave for distances under 10 miles was a cost-effective way to connect two schools.
- The major costs were (a) system consulting and design, (b) materials, construction, and installation, (c) terminal end point equipment, and (d) maintenance contracts.
- Distance significantly affected the costs of fiber and microwave. Both became cost-prohibitive ways to connect two sites as

distances increased.

- Compressed video system costs were the least affected by distance. Most of the costs for this technology were for compression/end-point equipment.
- Most experts recommended using digital technology, which offers superior quality.
- Fiber can be cost-effectively installed by schools short distances from each other.
- Urban fiber construction costs were greater than rural fiber construction costs.
- Microwave frequencies are not available in some cities.
- Leasing a building or tower for use as a repeater tower between two schools rather than constructing a tower decreased expenses.
- Leasing a repeater station required a large capital investment.
- There was variation in microwave repeater lease rates according to location.
- There was variation in land lease rates according to the location of microwave towers.
- Towers should be built as close to schools as possible.
- Installing and testing microwave systems was expensive.
- Long haul microwave systems were not cost-effective unless a repeater structure was leased inexpensively, and dishes were put on buildings.
- One hop microwave costs (1 - 30 miles) increased as the distance increased--higher towers and more powerful transmitters were needed.
- Microwave systems were the most susceptible to malfunctions, because they were most affected by weather.
- Telephone companies charged more than utility companies for fiber leases.
- Metropolitan areas, generally, had access to less expensive fiber leases than rural areas.
- Cost per mile for lease rates for DS1 & DS3 decreased as distance increased.
- Lease rates for DS3 were 3 to 8 times the monthly lease rate of DS1.

Conclusions about the interactive distance education classroom were that:

- Usually classrooms do not have to be completely remodeled to be distance

education classrooms.

- Basic equipment costs ranged from \$25,000 - \$30,000.
- Equipment was easily added or eliminated to fit budgets and needs.
- Packages of complete systems cost 30 to 70 percent more than the purchase of individual items.
- Maintenance is not a significant cost variable for classroom equipment.
- Transmission of computer generated signals significantly increased costs.
- There was variation in vendor's equipment packages in relation to capabilities, included options, and prices.

### Conclusions

If full motion video is essential for interactive distance education, microwave is the most viable solution for shorter distances. Even though microwave systems are affected by weather, they still are effective for linking two schools. Digital fiber is the best choice as far as quality and capacity, but high costs tend to negate this advantage. Fiber is the most complex to install; this complexity contributes to higher costs. High costs make fiber too expensive for two school systems to install without some outside financial assistance. Leasing fiber is appropriate if fiber is in place.

If compressed video is deemed a satisfactory transmission method, overall it is the least expensive to install and is a viable solution, no matter the distance. Compressed video is a cost appropriate solution for longer distances. Both fiber and microwave systems are somewhat cost prohibitive for longer distances.

The standard classroom is easily adapted for use as a distance education classroom without significant remodeling costs. A distance education classroom can be equipped for less than \$30,000.

Two-way, interactive television systems are expensive, complex and time-consuming to design, construct, and maintain. Once installed, however, they are neither difficult nor complex to use. With knowledgeable advice and sufficient planning, schools can have successful distance education programs. If the purpose of

choosing an interactive system is to reach students and provide instruction, all three approaches can attain that goal on a fairly equal basis. The success of any delivery system, of course, depends upon the quality and usefulness of the content delivered and received, rather than upon the choice of equipment.

#### BIBLIOGRAPHY

- Adams, C. R., Hankins, R. L. & Schroeder, R. G. (1978). The literature of cost and cost analysis in higher education. A study of cost analysis in higher education (Volume 1). Washington, DC: American Council on Education.
- Baath, J. A. (1980). Postal two-way communication in correspondence education. An empirical investigation. LiberHermods: Malmö. University of Lund, Dept. of Ed. (ERIC Document Reproduction Service No. ED 224 466)
- Barker, B. O. (1987). Using interactive technologies to increase course offerings in small and rural schools. Paper presented at the Seventh Annual Conference for Microcomputers and Technology in K-12 Education, Carbondale, IL. (ERIC Document Reproduction Service No. ED 279 465)
- Barker, B. O. (1989a). Distance education technologies: All that glitters is not gold. Paper presented at the 2nd Annual Meeting of the Decisions about Technology Conference, Bismark, ND. (ERIC Document Reproduction Service ED 309 894)
- Barker, B. O. (1989b). Distance learning case studies. Congress of the U.S. Washington DC: Office of Technology Assessment. (ERIC Document Reproduction Service No. ED 332 661)
- Barker, B. O. (1991). K-12 distance education in the United States: Technology strengths, weaknesses, and issues. Paper presented at the Annual International Conference on Distance Learning Association, Washington, DC. (ERIC Document Reproduction Service No. ED 332 687)
- Barron, D. D. (1989, November). Distance education: Removing barriers to knowledge. School Library Journal, 35, 28-33.
- Bates, A. (1988). Trends in the use of audio-visual media in distance education systems. In D. Sewart, D. Keegan & B. Holmberg (Eds.), Distance education: International perspectives (pp. 227-241). New York: Routledge.
- Batey, A. & Cowell, R. N. (1986). Distance education: An overview. Portland, Oregon: Northwest Regional Educational Lab. (ERIC Document Reproduction Service No. ED 278 519)
- Bowman, M. (1986, November). Televideo system signals opportunities for students. EITV, 18, 23-25.
- Brewster, R. L. (1986). Telecommunications technology. NY: Halsted Press, division of John Wiley & Sons.
- Burge, E., Snow, J. E., & Howard, J. L. (1989). Distance education: Concept and practice. Canadian Library Journal, 46, 329-335.
- Carter, R. (1992, February). The digital challenge--exploring digital compression for tv transmission. Paper presented to the AECT Convention, Washington, DC. Arizona State University, College of Extended Education.
- Catchpole, M. J. (1988). Student response to a distance education course incorporating live interactive television. In D. Sewart & J. S. Daniel (Eds.), Developing distance education (pp. 156-158). Paper presented at the World Conference of the International Council for Distance Education, Oslo, Norway. (ERIC Document Reproduction Service No. ED 320 544)
- Code of Federal Regulations. Telecommunication. Chapter 47. (1991). Office of the Federal Register, National Archives and Records Administration. Washington DC: U.S. Govt. Printing Office.

- Currer, J. M. (1991). Distance learning using digital fiber optics: Applications, technologies, and benefits. State Univ. of New York, Oneonta, Eastern Stream Center on Resources and Training. (ERIC Document Reproduction Service No. ED 332 845)
- Daley, A. (1991). Bringing the information age into schools: Broadband networks. Tech Trends 36 (2), 13-17.
- Daniel, J. S. (1988). Distance education and national development. In D. Sewart & J. S. Daniel (Eds.), Developing distance education (pp. 21-28). Papers submitted to the World Conference of the International Council for Distance Education, Oslo, Norway. (ERIC Document Reproduction Service No. ED 320 544)
- Descy, D. E. (1991). Two-way interactive television in Minnesota: The kids network. Tech Trends, 36, 44-48.
- Edwin, E. O. & Owens, W. B., & Rezabek, L. L. (1991). Compressed video: Basic questions and simple answers. Laramie, WY: University of Wyoming.
- Eicher, J. C. (1987). Costs of the new information technologies in education: Characteristics and problems of measurement. Paris, France: United Nations Educational, Scientific, and Cultural Organization. (ERIC Document Reproduction Service No. ED 315 050)
- Ely, D. P., Januszewski, A., & LeBlanc, G. (1988). Trends and issues in educational technology, 1988. Washington DC: Office of Educational Research and Improvement. ERIC Document Reproduction Service No. ED 308 859)
- Ernst & Young. (1991, March). Analysis of the project to establish a state communications network for education. Response to request from Iowa Legislative Council. Vienna, VA: Authors.
- Feasley, C. E. (1982). Distance education. Oklahoma City, OK: Oklahoma State University. (ERIC Document Reproduction Service No. ED 239 594)
- Feasley, C. (1983). Serving learners at a distance: A guide to program practices. (ASHE-ERIC Higher Education Research Report no. 5). Washington, DC: Association for the Study of Higher Education and ERIC Clearinghouse on Higher Education. (ERIC Document Reproduction Service No. ED 238 350)
- Fink, E. J. & Tsujimura, N. (1991, February). An interactive televised Japanese language class: Lessons learned by professor and director. Educational Technology, 31, 46-50.
- Fogarty, T. A. (1992, June 18). Lawsuit threatened: Sioux City cuts fiber optic plans. The Des Moines Register, p. 7M.
- Foks, J. (1988). Distance education--A developing concept. In D. Sewart & J. Daniel (Eds.), Developing distance education (pp. 31-37). Paper submitted to the World Conference of the International Council for Distance Education, Oslo, Norway. (ERIC Document Reproduction Service No. ED 320 544)
- Freeman, R. L. (1991). Telecommunication transmission handbook (3rd ed.). (Wiley Series in Telecommunications). NY: John Wiley & Sons.
- Garrison, D. R. (1989). Understanding distance education. London: Routledge.
- Giltrow, D. (1989). Distance education. Washington, DC: Association for Educational Communications and Technology. (ERIC Document Reproduction Service No. ED 310 753)
- Gray, R. A. (1988, May). Educational technology use in distance education: Historical review and future trends. Educational Technology, 28, 38-42.
- Greenwood, A. N. & McDevitt, M. A. (1987). Multiple teaching strategies for use with an instructional telecommunications network. Paper presented at the Society for Applied Learning Technology. (ERIC

- Document Reproduction Service No. ED 309 734)
- Hart, R. A. (1986). Sunrise to sunset lifelong learning via microwave networks: From a national heritage. Paper presented at the Annual Meeting of the American Association for Adult and Continuing Education, Hollywood, FL. (ERIC Document Reproduction Service No. ED 287 049)
- Hersfield, S. F. (1986, July). Distance education: The promise and the confusion! Paper presented at the 12th Annual International Conference on Improving University Teaching, Heidelberg, West Germany. (ERIC Document Reproduction Service No. ED 278 166)
- Hezel, R. T. (1991). Statewide planning for telecommunications in education: Some trends and issues. Tech Trends, 36(5), 17-20.
- Hobbs, V. M. (1990). Distance learning in North Dakota: A cross-technology study of the schools, administrators, coordinators, instructors, and students. Two-way interactive television, audiographic tele-learning, and instruction by satellite. Denver, CO: Mid-Continent Regional Educational Lab., Inc. (ERIC Document Reproduction Service No. ED 328 225)
- Holmberg, B. (1977). Distance education: A survey and bibliography. London: Kogan Page Limited.
- Holmberg, B. (1981). Status and trends of distance education. London: Kogan Page Limited.
- Holmberg, B. (1988a). Is distance education a mode of education in its own right or is it a substitute for conventional education? In D. Stewart & J. Daniel (Eds.), Developing distance education (pp. 245-248). Papers submitted to the World Conference of the International Council for Distance Education, Oslo, Norway. (ERIC Document Reproduction Service No. ED 320 544)
- Holmberg, B. (1988b). Guided didactic conversation in distance education. In D. Stewart, D. Keegan & B. Holmberg (Eds.), Distance education: International perspectives (pp. 114-122). New York: Routledge.
- Hudson, H. E. & Boyd, C. H. (1984). Distance learning: A review for educators. Austin, TX: Southwest Educational Development Lab. (ERIC Document Reproduction Service No. ED 246 872)
- Hudspeth, D. R. & Brey, R. G. (1986). Instructional telecommunications: Principles and applications. New York: Praeger Publishers.
- Hughes, A. L. (1988, April). The crisis of distance learning--A dangerous opportunity. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA. (ERIC Document Reproduction Service ED 304 128)
- Iowa Administrative Code. (1990, June 6). Use of telecommunications for instruction by schools. 281 Chapter 15.1(256). (Loose-leaf).
- Iowa. Code of Iowa (1991). Containing all statutes of a general and permanent nature: including the acts of a permanent nature of the Seventy-Third General Assembly, 1989-1990. Des Moines: General Assembly of Iowa, Legislative Service Bureau.
- Iowa Department of Education. (1991, December). Education is Iowa's future: The state plan for educational excellence in the 21st century. Des Moines, IA: Author.
- Iowa General Assembly. (1987a). Senate File 333. Telecommunications use by schools, area schools, and regents' institutions. Laws of the Seventy-Second General Assembly. Des Moines: General Assembly of Iowa, Legislative Service Bureau.
- Iowa General Assembly. (1987b). Senate File 162. Iowa Public Broadcasting. Laws of the Seventy-Second General Assembly. Des Moines: General Assembly of Iowa, Legislative Service Bureau.
- Iowa General Assembly. (1989). House File 774. Appropriations and other provisions

- relating to educational and cultural programs. Laws of the Seventy-Third General Assembly. Des Moines: General Assembly of Iowa, Legislative Service Bureau.
- Iowa General Assembly. (1990). Senate File 2280. Appropriations and provisions relating to state executive agencies and national organizations. Laws of the Seventy-Third General Assembly. Des Moines: General Assembly of Iowa, Legislative Service Bureau.
- Iowa Telephone Association. (1990, December 19). Iowa telecommunications industry illustrative example for the Iowa Communications Network. Presented at the final meeting of the Telecommunications Oversight Study Committee. Des Moines, IA: Authors.
- Jefferson, F. E. & Moore, O.K. (1990, September). Distance education: A review of progress and prospects. Educational Technology, 30, 7-12.
- Jurasek, K. (1992). The evolution of a compressed video system: The attitudes and perceptions of students and faculty. Unpublished master's thesis, Iowa State University, Ames, Iowa.
- Kabat, E. J. & Friedel, J. N. (1990). The Eastern Iowa community college district's (EICCD) televised interactive education (TIE) evaluation report, 1989-1990. Eastern Iowa Community College, District Office of Academic Affairs and Planning. District, Bettendorf. (ERIC Document Reproduction Service No. ED 327 167)
- Kaye, A. & Rumble, G. (Eds.). (1981). Distance teaching for higher and adult education. London: Croom Helm.
- Keegan, D. (1980). On the nature of distance education. (ZIFF Papiere 33). FernUniversität, Hagen (West Germany): Zentrales Inst. für Fernstudienforschung Arbeitsbereich. (ERIC Document Reproduction Service No. ED 311 890)
- Keegan, D. (1986). The foundations of distance education. London: Croom Helm.
- Keegan, D. (1988). Theories of distance education. Introduction. In D. Sewart, D. Keegan & B. Holmberg (Eds.), Distance education: International perspectives (pp. 63-65). New York: Routledge.
- Kiesling, Herbert (1979). Economic cost analysis in higher education: The University of Mid-America and traditional institutions compared. Educational Communication and Technology, 27(1), 9-14.
- Keller, C. A., Staab, M. G., & Stowe, R. A. (1989, June). A comparative study of compression video technology. Muncie, IN: Ball State University, Center for Information and Communication Sciences. (ERIC Document Reproduction Service No. ED 319 361)
- Kitchen, W. (1987, March 7). Education and telecommunications: Partners in progress. Testimony to the Senate Committee on Labor and Human Services. (ERIC Document Reproduction Service No. ED 282 551)
- Kitchen, K. and Kitchen, W. (1988, May). Two-way interactive television for distance learning: A primer. (An ITTE Technology Leadership Network Special Report from The Institute for the Transfer of Technology to Education of the National School Boards Association). Alexandria, VA: ITTE Technology Leadership Network.
- Kober, N. (1990, November). Think rural means isolated? Not when distance learning reaches into schools. The School Administrator, 10, 17-24.
- Kolomeychuk, T. & Peltz, D. P. (1991). Assessing the effectiveness of interactive compressed video at the University of Minnesota. (TDC Research Report No. 20). Minnesota Extension Service, University of Minnesota, Telecommunications Development Center.
- Lanier, R. (1986, June). Interactive telesystem breaks new ground. E-ITV, 18, 35-38.

- Lewis, R. J. (1983). Meeting learners' needs through telecommunications: A directory and guide to programs. Washington, DC: American Association for Higher Education. (ERIC Document Reproduction Service No. ED 227 731)
- Markowitz, H. Jr. (1990). Distance education: Staff handbook. (The Guide Series in Continuing Education). Urbana, IL: Illinois University, Office of Continuing Education and Public Services. (ERIC Document Reproduction Service No. ED 323 334)
- Minnesota State Department of Education. (1988). Implementing interactive television. (Integrating Technology Series). St. Paul, MN: Author (ERIC Document Reproduction Service No. 311 879)
- Minnesota State Department of Education. (1990). Distance education for all ages in Minnesota: The K-12 systems perspective. St. Paul, MN: Author.
- Moore, C. E. & McLaughlin, J. M. (1992). Interactive two-way television: Extending the classroom through technology. T.H.E. Journal, 19, 74-76.
- Moore, M. (1988). On a theory of independent study. In D. Sewart, D. Keegan & B. Holmberg (Eds.), Distance education: International perspectives (pp. 68-94). New York: Routledge.
- Moore, M. G. & Thompson, M. M. (1990). The effects of distance learning: A summary of literature. (Research Monograph Number 2). Southeastern Ohio Telecommunications Consortium.
- National Governors' Association. (1986, August). Time for results: The governors' 1991 report on education. Washington, DC: National Governor's Association, Center for Policy and Analysis. (ERIC Document Reproduction Service No. ED 279 603)
- National School Board Association. (1989). Planning for telecommunications: A school leader's primer. Portland, Oregon: US West Communications.
- Nelson, C. L., Cvancara, J. G., & Peters, D. (1989). Electronic face-to-face inservice education. Paper presented at the Annual Meeting of the American Vocational Association, Orlando, FL. (ERIC Document Reproduction Service No. ED 314 611)
- Nelson, R. N. (1985, November). Two-way microwave transmission consolidates, improves education. NASSP Bulletin, 69, 38-42.
- Oaks, M. (1986). Interactive microwave: Extending the institution to the state. Paper presented to the Joint Northwest Adult Education Association and Pacific Association for Continuing Education, Vancouver, British Columbia: Canada. (ERIC Document Reproduction Service No. ED 275 279)
- Ostendorf, V. A. (1989a). What every principal, teacher and school board member should know about distance education. Littleton, CO: Author.
- Ostendorf, V. A. (1989b). Teaching through interactive television: A practical introduction to business television and distance education. Littleton, CO: Author.
- Pelton, Joseph N. (1990). Technology and education: Friend or foes? Paper presented at the 15th World Congress of the International Council for Distance Education, Caracas, Venezuela. (ERIC Document Reproduction Service No. ED 330 302)
- Perraton, H. (1982). The cost of distance education. (IEC Broadsheet on Distance Learning No. 17). Cambridge: International Extension College.
- Peters, O. (1988). Distance teaching and industrial production; A comparative interpretation in outline. In D. Sewart, D. Keegan & B. Holmberg (Eds.), Distance education: International perspectives (pp. 95-113). New York: Routledge.
- Phillips, D. L. (1987, April). Videoconferencing at Penn State. T.H.E. Journal, 14, 52-54.

- Pinkerton, T. (1992). Report on video teleconferencing. Madison, WI: University of Wisconsin-Madison, Division of Information Technology.
- Pirrong, G. D. & Lathen, W. C. (1990). The use of interactive television in business education. Educational Technology, 30, 49-54.
- Price, M. A. (1991, January). Designing video classrooms. Adult Learning, 2, 15-19.
- Randall, R. & Valdez, G. (1988). Evaluation and implementation findings of Minnesota's distance learning demonstration sites. In D. Sewart & J. S. Daniel (Eds.), Developing distance education (pp. 378-380). Papers submitted to the World Conference of the International Council for Distance Education, Oslo, Norway. (ERIC Document Reproduction Service No. ED 320 544)
- Roos, J. (1991, October 14). DMACC says it can't afford optics system. The Des Moines Register, p. 6M.
- Roos, J. (1991, December 7). Fiber-optic network's backbone should be finished, panel says. The Des Moines Register, p. 2M.
- Rumble, G. (1982). The cost analysis of learning at a distance: Venezuela's Universidad Nacional Abierta. Distance Education, 3(1), 116-140.
- Rumble, G. (1986a). Costing distance education. Education Division, Human Resource Development Group, Commonwealth Secretariat. Pall Mall, London: Marlborough House.
- Rumble, G. (1986b). The planning and management of distance education. London: Croom Helm.
- Rumble, G. (1989). On defining distance education. The American Journal of Distance Education, 3, 8-21.
- Rumble, G. & Harry, K. (1982). The distance teaching universities. London: Croom Helm.
- Sewart, D. (1988). Distance teaching: A contradiction in terms? In D. Sewart, D. Keegan & B. Holmberg (Eds.), Distance education: International perspectives (pp. 46-61). New York: Routledge.
- Shobe, C. R. (1986). New technologies in distance education. In I. Mugridge & D. Kaufman (Eds.), Distance education in Canada (pp. 215-233). London: Croom Helm.
- Smith, M. H. (Ed.). (1961). Using television in the classroom. (Midwest Program on Airborne Television Instruction). New York: McGraw-Hill.
- Szentesi, O. I. (1991). Trends in fiber-optic technology. In J. W. Conard (Ed.), Handbook of communications systems management (2nd ed.) (p. 485-499). Boston: Auerbach.
- Todd Communications. (1992). [Brochures]. (Order from TODD Communications, Inc. 6545 Cecilia Circle, Minneapolis, MN 55439)
- Tomasi, W. & Alisouskas, V. F. (1988). Telecommunications: Voice/data with fiber optic applications (pp. 304-329). Englewood Cliffs, NJ: Prentice Hall.
- Turnbull, A. J. (1988). Distance education--The trend setter. In D. Sewart & J. S. Daniel (Eds.), Developing distance education (pp. 429-431). Papers submitted to the World Conference of the International Council for Distance Education, Oslo, Norway. (ERIC Document Reproduction Service No. ED 320 544)
- Tykwinski, J. R. & Poulin, R. C. (1991). North Dakota interactive video network: A practical guide to teleconferencing and distance education. Bismarck, ND: North Dakota University.
- U.S. Congress, Office of Technology Assessment. (1989). Linking for learning: A new course for education. (OTA-SET-430). Washington, DC: U. S. Government Printing Office. (ERIC Document Reproduction Service No. ED 310 765)

- Wagner, E. D. (1989). Instructional design and development: Contingency management for distance education. In National School Board Association, Planning for telecommunications: A school leader's primer (Appendix A). Portland, Oregon: U S West Communications.
- Wagner, L. (1982). The economics of educational media. London: The Macmillan Press Ltd.
- Wakamatsu, S. & Obi, S. (1990). Classroom tutorials by 64 kbps videoconferencing. In D. J. Wedemeyer & M. D. Lofstrum (Eds.), Pacific telecommunications: Weaving the technological and social fabric (pp. 651-653). Proceedings of the 12th Annual Conference of the Pacific Telecommunications Council, Honolulu, HA. (ERIC Reproduction Document Service No. ED 320 566)
- Wallin, D. L. (1990, July-September). Televised interactive education: Creative technology for alternative learning. Community/Junior College Quarterly of Research and Practice, 14, 259-265.
- Ward, J. (1990, May 9). Landline two-way video: Being there--and here. T.H.E. Journal, 17, 59-61.
- Wedemeyer, C. A. (1981). Learning at the back door: Reflections on nontraditional learning in the lifespan. Madison: University of Wisconsin Press.
- Weeks, J. P. (1987). Continuing professional education delivery systems. Pennsylvania State University, University Park. Office of Continuing Professional Education. (ERIC Document Reproduction Service No. ED 297 093)
- Wood, D. N. & Wylie, D. G. (1977). Educational telecommunications. Belmont, California: Wadsworth Publishing Company.
- Yepsen, D. & Roos, J. (1991, November 9). Branstad still for fiber-optics system in Iowa. The Des Moines Register, p. 6M.
- Zigerell, J. (1984). Distance education: An information age approach to adult education. Columbus, OH: ERIC Clearinghouse on Adult, Career, and Vocational Education, National Institute of Education. (ERIC Document Reproduction Service No. ED 246 311)

FIGURES

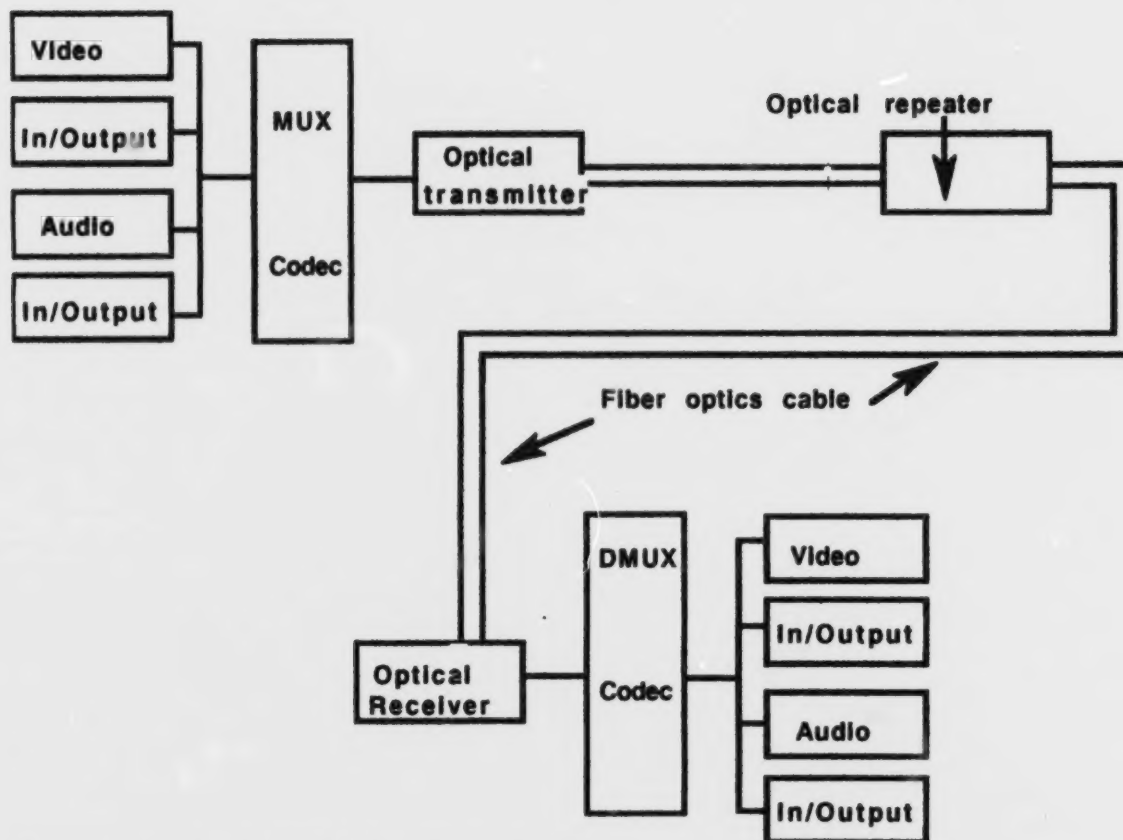


Figure 1. Point to point digital fiber optics system

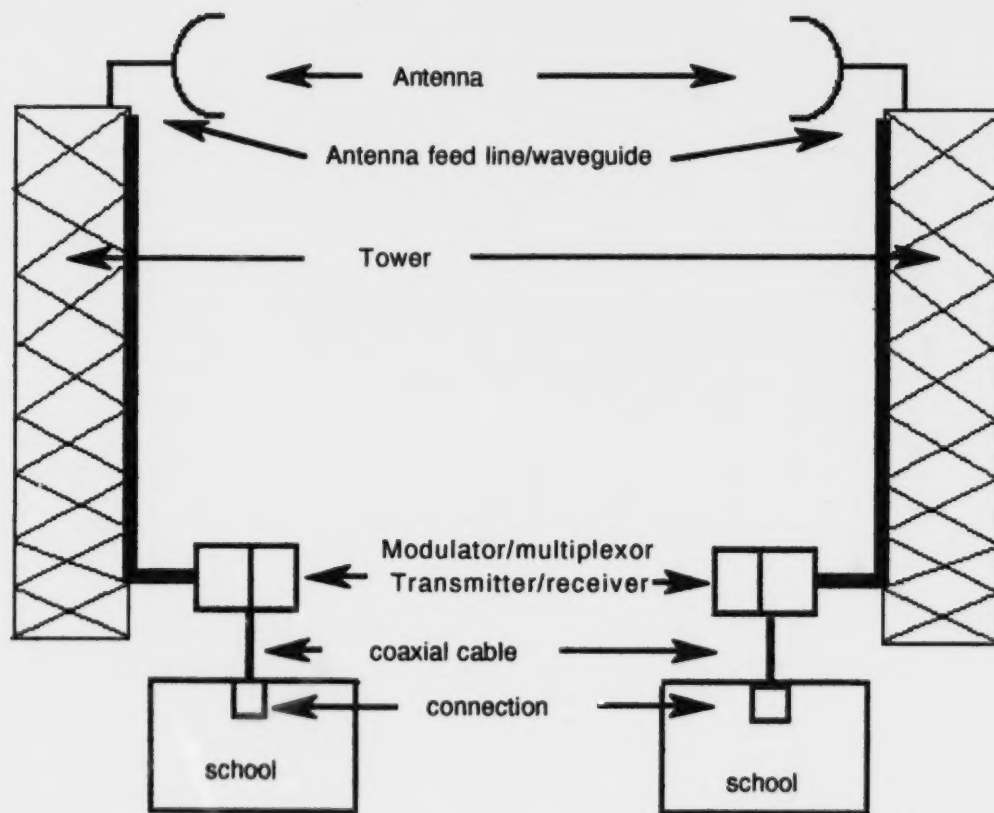


Figure 2. Point-to-point microwave system

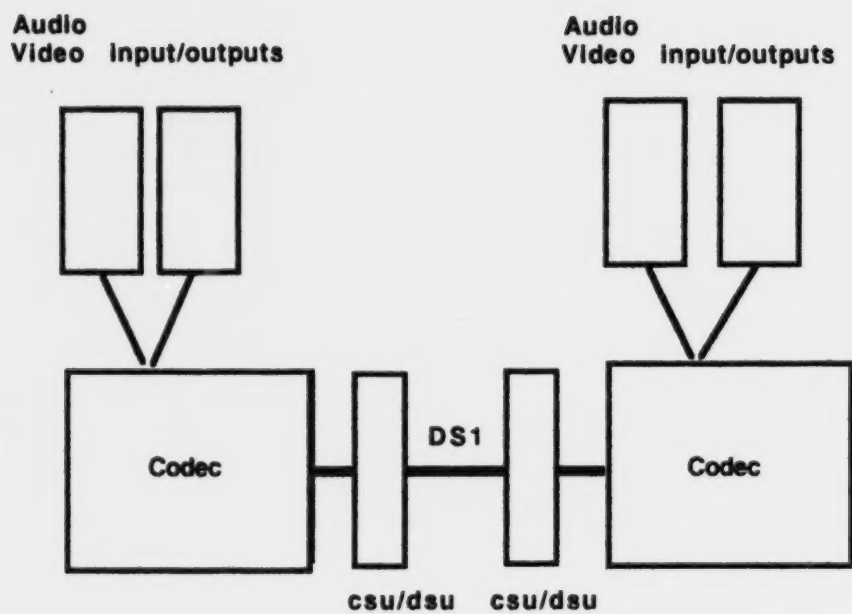


Figure 3. Compressed video system

TABLE

Table 1. Comparison of digital fiber, digital microwave, and DS1 compressed video costs

| Distance | Transmission medium | Purchase <sup>a</sup><br>costs for<br>two sites | End point <sup>b</sup><br>costs for<br>two sites | Lease <sup>c</sup><br>for<br>two sites | First year<br>total costs <sup>d</sup><br>two sites | 2nd year<br>costs <sup>e</sup><br>for two sites | 5 Year<br>costs for two<br>sites <sup>d</sup> | Average<br>cost per year<br>5 year period |
|----------|---------------------|-------------------------------------------------|--------------------------------------------------|----------------------------------------|-----------------------------------------------------|-------------------------------------------------|-----------------------------------------------|-------------------------------------------|
| 3 miles  | Fiber, purchased    | 66,000                                          | 72,000                                           |                                        | 138,000                                             |                                                 | 138,000                                       | 27,600                                    |
|          | Fiber, leased       |                                                 | 12,000                                           | 36,000                                 | 48,000                                              | 33,000                                          | 180,000                                       | 36,000                                    |
|          | Microwave           | 35,000                                          |                                                  |                                        | 35,000                                              |                                                 | 35,000                                        | 7,000                                     |
|          | Compressed DS1      |                                                 | 72,000                                           | 7,500                                  | 79,500                                              | 4,500                                           | 97,500                                        | 19,500                                    |
| 10 miles | Fiber, purchased    | 212,000                                         | 72,000                                           |                                        | 284,000                                             |                                                 | 284,000                                       | 56,800                                    |
|          | Fiber, leased       |                                                 | 12,000                                           | 38,000                                 | 50,000                                              | 35,000                                          | 190,000                                       | 38,000                                    |
|          | Microwave           | 41,000                                          |                                                  |                                        | 41,000                                              |                                                 | 41,000                                        | 8,200                                     |
|          | Compressed DS1      |                                                 | 72,000                                           | 8,700                                  | 80,700                                              | 5,700                                           | 103,500                                       | 20,700                                    |
| 20 miles | Fiber, purchased    | 415,000                                         | 72,000                                           |                                        | 487,000                                             |                                                 | 487,000                                       | 97,400                                    |
|          | Fiber, leased       |                                                 | 12,000                                           | 41,000                                 | 53,000                                              | 38,000                                          | 205,000                                       | 41,000                                    |
|          | Microwave           | 166,000                                         |                                                  |                                        | 166,000                                             |                                                 | 166,000                                       | 33,200                                    |
|          | Compressed DS1      |                                                 | 72,000                                           | 10,300                                 | 82,300                                              | 7,300                                           | 111,500                                       | 22,340                                    |
| 30 miles | Fiber, purchased    | 615,000                                         | 72,000                                           |                                        | 687,000                                             |                                                 | 687,000                                       | 137,400                                   |
|          | Fiber, leased       |                                                 | 12,000                                           | 48,000                                 | 60,000                                              | 45,000                                          | 240,000                                       | 48,000                                    |
|          | Microwave           | 213,000                                         |                                                  |                                        | 213,000                                             |                                                 | 213,000                                       | 42,600                                    |
|          | Compressed DS1      |                                                 | 72,000                                           | 13,000                                 | 85,000                                              | 10,000                                          | 125,000                                       | 25,000                                    |
| 50 miles | Fiber, purchased    | 993,000                                         | 72,000                                           |                                        | 1,065,000                                           |                                                 | 1,065,000                                     | 213,000                                   |
|          | Fiber, leased       |                                                 | 12,000                                           | 54,000                                 | 66,000                                              | 51,000                                          | 270,000                                       | 54,000                                    |
|          | Microwave           | 357,000                                         |                                                  |                                        | 357,000                                             |                                                 | 357,000                                       | 71,400                                    |
|          | Compressed DS1      |                                                 | 72,000                                           | 16,000                                 | 88,000                                              | 13,000                                          | 140,000                                       | 28,000                                    |
| 75 miles | Fiber, purchased    | 1,431,000                                       | 72,000                                           |                                        | 1,503,000                                           |                                                 | 1,503,000                                     | 300,600                                   |
|          | Fiber, leased       |                                                 | 12,000                                           | 76,000                                 | 88,000                                              | 73,000                                          | 380,000                                       | 76,000                                    |
|          | Microwave           | 493,000                                         |                                                  |                                        | 493,000                                             |                                                 | 493,000                                       | 98,600                                    |
|          | Compressed DS1      |                                                 | 72,000                                           | 20,000                                 | 92,000                                              | 17,000                                          | 160,000                                       | 32,000                                    |

<sup>a</sup> Purchase costs refer to all construction, material, and equipment (not end point) costs involved in building the system.

<sup>b</sup> End point costs include transmission equipment, hardware, cables, and power supply, plus codecs which change analog signals to digital signals and compress the signal.

<sup>c</sup> This price reflects one time connection fee.

<sup>d</sup> No maintenance or operating costs are included for purchased systems; lease costs include maintenance and operating costs.

<sup>e</sup> One year lease rate for contract period of 60 months.

## APPENDIX A - The Iowa Communication Network

Brief history. In 1986, the Iowa General Assembly decided it was important to have statewide direction for a telecommunications system. Legislators allocated \$200,000 to develop the long range plan. This project was headed by Larry Patten, former head of Iowa Public Broadcasting. Patten examined the concept of a statewide telecommunications network for the enhancement of education in Iowa. The final report of this project was presented to the Iowa General Assembly in August 1987.

On June 5, 1987, Iowa's Governor Terry Branstad signed into law Senate File 162, which established the Iowa Public Broad-casting Board and gave the Board authority for the ICN (Iowa General Assembly, 1987b). In this coordinating role, the Iowa Public Broadcasting Board provides assistance in planning, establishing, and operating the ICN (Iowa. Code of Iowa, 1991, §303.77). To comply with this mandate, the Narrowcast Advisory Committee was created to insure proper linkages between the state coordinating body (Iowa Public Television), the local coordinating bodies (the community colleges), and users of the system. Also signed into law at this time was Senate File 333, which provided policies and procedures for the telecommunications delivery system (Iowa General Assembly, 1987a).

ICN construction and use. The ICN utilizes live, two-way interactive, full motion video that will connect students and teachers across the state. The ICN is to be built in three phases (Iowa. Code of Iowa, 1991, §18.136(2)). Phase I extends from the hub at Camp Dodge to the state's 15 area community colleges, the three regent universities, and Iowa Public Television (IPT). It utilizes a fiber optic backbone. Phase II extends from each area college to a single point in each of the state's 99 counties. Phase III connects the county points to individual state agencies, schools, and libraries in surrounding areas. Completion date for the ICN Phases I and II is set for fall 1993; the completed network will be 2,600 miles in length. Future expansion possibilities include the connection of public or private schools, colleges, libraries, or service organizations.

The Iowa Department of Education published

Chapter 15 *Use of Telecommunications for Instruction by Schools*, which was adopted June 6, 1990. These rules give guidance and direction for the use of telecommunications as an instructional tool for students enrolled in kindergarten through grade 12. These rules specify that courses delivered via telecommunications shall employ live, interactive systems which allow, at a minimum, one-way video and two-way audio communication (Iowa Administrative Code, 1990).

Currently, the Iowa Department of Education offers no standards, mandates, designs, or criteria for the distance education classroom. However, the future role of the Iowa Department of Education in assisting school officials with distance education systems will expand. The department's focus and mission towards distance education is increasing (E. Eriksen, Iowa Department of Education, personal communication, February 6, 1992). In the *State Plan for Educational Excellence* (Iowa Department of Education, 1991), the importance of distance education is recognized. "One of the most promising [technology] for use in Iowa is distance learning technology" (p.20).

Schools in Iowa that are developing distance education systems must first send a plan to the Narrowcast Committee for approval. The plan must be consistent with the existing state system (Iowa. Code of Iowa, 1991, §18.136 (8)). Connection to the ICN will be implemented through local area community colleges. Schools in Phases I and II are currently being surveyed concerning hook-up. Site teams are visiting these locations, checking ICN termination points, completing fiber path studies, completing designs for approval, and setting time tables for installation completion (L. Schatz, personal communication, May 18, 1992).

Financing the ICN. The Iowa Code (1991, §18.136 (3)) defines financing for the ICN. The State will pay the entire costs of Phase I. Phases II and III will utilize an 80/20 percent financing plan for procurement and maintenance. The State will furnish 80 percent of the costs, and 20 percent of the costs will come from the community district being served. Because of the availability of existing technology and the variables of distance, there

will be substantial cost differences for Phase III installations. The Iowa Code (1991, §18.136 (3)) states that Phase I and Phase II must be completed before matching funds will be provided for Phase III sites.

Classroom equipment is not part of the financed state project, but is a local cost. House File 774 provides for construction costs, not operation costs (Iowa General Assembly, 1989). Construction costs include fiber installation and transmission terminal equipment (codecs). Local and regional districts are responsible for classroom costs such as cameras, monitors, and audio equipment.

The Iowa Distance Education Alliance - The Star Schools Program. In 1992, \$4 million grant from the U. S. Department of Education (Star Schools program), with the potential for a second year's funding also for \$4 million, was received to assist Iowa schools, colleges, and universities use the ICN. The proposal was written by a team of Iowa Educators coordinated by staff from the Research Institute for Studies in Education from the College of Education at Iowa State University. The grant will provide funding for classroom equipment, training for teachers, and an information clearinghouse. The Iowa Distance Education Alliance is an organization of Iowa education groups who will manage the Star Schools Program grant and use its funds to initiate the widespread use of the ICN.

Controversy surrounding the ICN. Controversy concerning need, financing, and technology has plagued the ICN since its inception. The Narrowcast Committee emphatically stated that the superb quality of the optic fiber with minimal distortion of color, sound, and motion was essential for learning.

On December 19, 1990, Kiewit Network Technology was notified of the intent to award the contract for construction of the ICN fiber backbone. Before the contract was signed, however, the Iowa Telephone Association (1990) presented to the General Assembly their opposition to the proposed contract for the ICN. Their opposition centered around the use of optic fiber. Their alternative, compressed video utilizing existing copper telephone lines, was currently available for lease to many

schools.

Before entering into a contract agreement, the Legislative Council on January 10, 1991, requested a comprehensive financial analysis of the ICN project by the independent consulting firm of Ernst & Young. The Ernst & Young (1991) report found compressed video unacceptable for educational purposes. "Full motion video will continue to be superior to compressed video for educational purposes for the foreseeable future" (p. ES-2). Ernst and Young recommended that key issues, such as the financial analysis period, the future availability of services from telephone carriers, and Phase III technology options, be reviewed as the system progressed.

On April 15, 1991, Kiewit Network Technology and Iowa Department of General Services signed a contract for construction of Phases I and II of the ICN. Their bid was for over \$89 million. The Legislature passed a budget bill that deauthorized funds for the ICN for 1992. Iowa's Governor Branstad item-vetoed this portion of the bill on May 31, 1991. Construction began in October 1991.

Current status. Controversy continues on the cost and necessity of the ICN. On October 14, 1991, Des Moines Area Community College abandoned the ICN plan, citing lack of funds (Roos, 1991, October). In November 1991, the Governor's Committee on Government Spending Reform, commonly referred to as the Fisher Commission, recommended that Phases I and II of the network proceed (Roos, 1991, December). Also in November, the Iowa Association of Community College Trustees gave their continued support for the network (Yepsen & Roos, 1991, November 9). In May 1992, the Sioux City, Iowa, City Council voted to deny permission for Kiewit to lay fiber in their city, subsequently affecting connections to five other counties (Fogarty, 1992, June 18).

Construction continues on the fiber backbone of Phases I and II. A 20-year bond has been issued to pay Kiewit Network Technology's construction expenses. Although the transmission method specified for Phase III sites is ITFS, it is expected that this method will be reevaluated at a future date since officials have concerns that ITFS may not be a satisfactory medium for the Phase III points.

(Note: ITFS as it is implemented in Iowa employs one-way video (i.e., broadcast)).

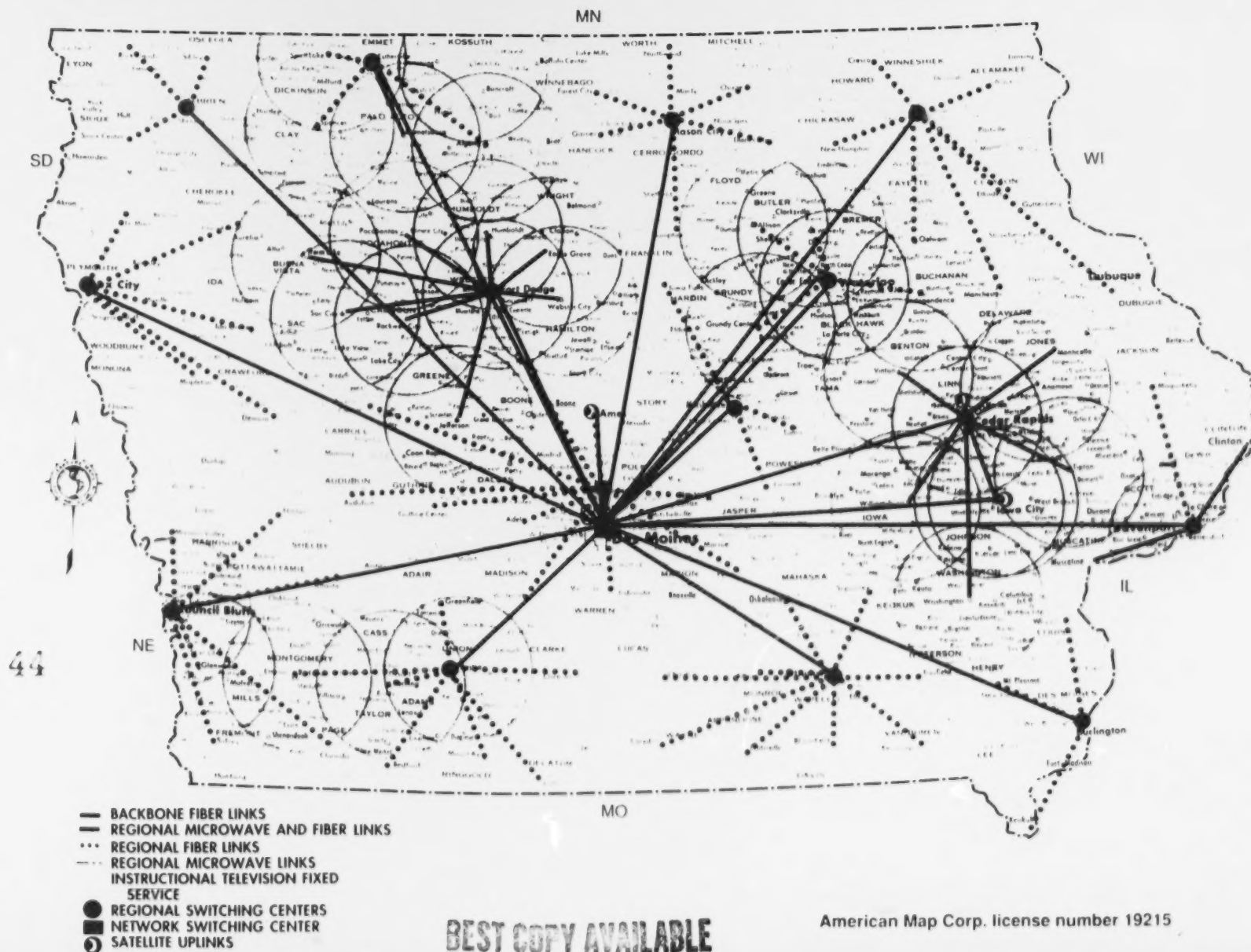
The 80/20 financing plan specified in the Iowa Code for Phase III sites is contingent upon ITFS usage. Unless the current law is changed, schools wanting a transmission medium other than ITFS would need to finance the system 100 percent.

State funding for the Phase III schools currently seems remote and completion of phase III of the ICN is not imminent. Many schools are looking at other options for interactive systems. For example, Des Moines schools are creating a digital cluster, leasing fiber from public utilities. Other schools are looking into microwave, fiber, and compressed video systems.

For schools that are not one of the original 103 points of presence, other options may need to be explored. One solution that has had success in other states is the cluster concept, where schools form their own small groups; this clustering facilitates the implementation of the program and serves as a support network.

Analog microwave, analog fiber, and multipoint compressed video clusters can all hook into the ICN with the correct interface. These sites can successfully receive signals and interact on the ICN, although they will not be able to be originate.

# ICN/Iowa Educational Telecommunications Network



## APPENDIX B - Sources

#### PERSONAL INTERVIEW SOURCES

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Iowa State University  
Ames IA 50011  
515-294-8213

Brady Bruce  
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Richard Burt  
Electronic Engineering Company  
Motorola Communications  
5th & Burnett  
Ames IA 50010  
515-233-2337

Donald Campbell  
Alcatel Network Systems, Inc.  
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Richardson TX 75083  
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Engineering Consultant  
US West Communications  
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Tony Crandall  
Iowa Dept. of General Services  
Communications  
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Matt Darbyshire  
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Thomas Dombrowsky  
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## APPENDIX C - Considerations For Distance Education Systems

## CONSIDERATIONS FOR SETTING UP A DISTANCE EDUCATION SYSTEM

### Fiber System

1. **FEASIBILITY STUDY.** This is a planning stage. Specific options to consider are:
  - \* Service needs
  - \* Economic and technical aspects
  - \* Procuring easements from the railway or state, city or county
  - \* Contacting individuals currently utilizing fiber systems
  - \* Leasing from individual telephone companies, utility companies, cable companies, and large businesses
  - \* Researching all possible partnerships and funding sources
  - \* Growth requirements
2. **SYSTEM DESIGN.** This includes determining specifications, routing distances, and estimating costs. Specific decisions and concerns include:
  - \* Type of system - analog or digital
  - \* Transmission distance
  - \* Type of fiber - single mode or multimode, step index or graded index
  - \* Type of optical equipment - LED or ILD; PIN or APD
  - \* Modulation type and code format; wavelength
  - \* Path coordinates
  - \* Detail map of route
  - \* Easements for roadways and railroads
  - \* If leasing, negotiate contract with conditions on rates, maintenance, service priority, and time periods
3. **PURCHASE AND INSTALL.** This phase involves actually putting the fiber into the ground, tying the system together with terminal equipment, and testing the system. Specific concerns are:
  - \* Method of installation
  - \* Staking the route
  - \* Splices or connectors
  - \* Installing the fiber
  - \* Terminal equipment - cost and technical support
  - \* Initial check of the system to see if it works
  - \* Maintenance agreement/fees
  - \* Warranty
  - \* Maintenance support
  - \* Compatibility of end point equipment with classroom equipment

### Microwave System

1. **FEASIBILITY STUDY.** This is the planning stage. The following are options to consider:
  - \* Service needs
  - \* Economical and technical aspects
  - \* Funding and financial planning
  - \* Contacting individuals currently utilizing microwave systems
  - \* Availability of frequencies or leasing facilities
  - \* Land topography and distance
  - \* Growth requirements
  - \* Availability of suitable sites for repeater stations

2. **SYSTEM DESIGN.** This includes determining specifications, locating points, and estimating costs. Specific decisions and concerns include:
  - \* Type of system - analog or digital
  - \* The distance and number of repeaters needed
  - \* Selection of sites - must be line-of-sight with no obstructions as trees, or buildings
  - \* Visual check of lease possibilities and obstructions
  - \* Frequency band study to find other frequencies that might interfere
  - \* Setting frequency
  - \* Path profile to determine tower height and check for obstructions - use topographical map to determine elevations and plot points
  - \* Tower specifications, e.g., wind and ice load
  - \* Path calculations to determine equipment parameters/ configurations to meet performance requirements, e.g., antenna size, transmitter power output, receiver noise figure, required bandwidth
  - \* Path survey to provide information vital to installation; review above calculations and specifications
  - \* If leasing, negotiate contract with rates, maintenance, service priority, and time periods
3. **PURCHASE AND INSTALL.** This phase involves the actual construction of the tower, installing transmission and terminal equipment, and testing equipment. Specific decisions and concerns include:
  - \* Acquiring land-lease or buy
  - \* Availability of power and access road
  - \* Getting FAA clearance
  - \* Filing FCC application which includes an interference analysis and system design
  - \* FCC tower construction application if over 200 feet
  - \* Constructing the tower - consider time schedule
  - \* Installing the transmission equipment; build protective building
  - \* Beam alignment, equipment lineup and checkout
  - \* Connections from tower to school
  - \* Hooking up cable in classroom
  - \* System warranty
  - \* Maintenance agreement/fees
  - \* Maintenance support

### **Compressed Video System**

1. **FEASIBILITY STUDY.** This is the planning stage. The following are options to consider:
  - \* Service needs
  - \* Economic and technical aspects
  - \* Possibilities for leasing the cable
  - \* Cost-sharing between two sites
  - \* Deciding if compressed video has the quality needed for the determined educational use
  - \* Contacting individuals currently utilizing compressed video systems

2. **SYSTEM DESIGN.** This includes determining equipment specifications, estimating costs, and negotiating contracts. The following are specific decisions and concerns:
  - \* Transmission equipment (codec) - purchase or lease
  - \* Transmission rate - 112 kb/s, 384 kb/s, 1.544 Mb/s
  - \* Dial up or dedicated line
  - \* P x 64 standards for interoperability/proprietary standards
  - \* Full or fractional T lease
3. **PURCHASE AND INSTALL.**
  - \* Leasing T1 lines - negotiate rates, maintenance, service priority, time periods
  - \* Installing equipment - time schedule, costs
  - \* Technical support for installation equipment
  - \* Purchasing own classroom equipment or vendor video package
  - \* Compatibility of all equipment in system
  - \* Upgrading capabilities
  - \* Technical hardware and software service support
  - \* Warranty on equipment
  - \* Maintenance agreement/fees

## APPENDIX D - Cost Estimates For Fiber Systems

# FIBER OPTIC AND VIDEO EQUIPMENT INSTALLATION COSTS

| FIBER OPTIC CABLE INSTALLATION COSTS                                                                     |                      |                                       |                     |                    |          |             |         |           |                           |                       |
|----------------------------------------------------------------------------------------------------------|----------------------|---------------------------------------|---------------------|--------------------|----------|-------------|---------|-----------|---------------------------|-----------------------|
|                                                                                                          |                      |                                       |                     | CONSULTATION COSTS |          |             |         |           |                           |                       |
| RURAL AREAS                                                                                              |                      |                                       |                     |                    |          |             |         |           |                           |                       |
| DISTANCE MI                                                                                              | CONSTRUCTION COST/FT | CONSTRUCTION COST/MI                  | CONSTR' N TECHNICAL | FIELD WORK         | DRAFTING | ENGINEERING | OTHER   | MATERIALS | TOTAL ESTIMATED COST/MILE | TOTAL ESTIMATED COSTS |
| 3                                                                                                        | \$1.55               | \$8,184                               | \$600               | \$850              | \$650    | \$1,000     | \$1,000 | \$9,672   | \$21,956                  | \$65,868              |
| 10                                                                                                       | \$1.40               | \$7,392                               | \$600               | \$850              | \$650    | \$1,000     | \$1,000 | \$9,672   | \$21,164                  | \$211,640             |
| 20                                                                                                       | \$1.35               | \$7,128                               | \$600               | \$800              | \$600    | \$950       | \$1,000 | \$9,672   | \$20,750                  | \$415,000             |
| 30                                                                                                       | \$1.30               | \$6,864                               | \$600               | \$800              | \$600    | \$950       | \$1,000 | \$9,672   | \$20,486                  | \$614,580             |
| 50                                                                                                       | \$1.21               | \$6,389                               | \$600               | \$750              | \$550    | \$900       | \$1,000 | \$9,672   | \$19,861                  | \$993,040             |
| 75                                                                                                       | \$1.09               | \$5,755                               | \$600               | \$700              | \$500    | \$850       | \$1,000 | \$9,672   | \$19,077                  | \$1,430,790           |
| 100                                                                                                      | \$0.97               | \$5,122                               | \$600               | \$700              | \$500    | \$850       | \$1,000 | \$9,672   | \$18,444                  | \$1,844,360           |
| CONSTRUCTION: DIRECT BURY CABLE ALONG RURAL ROW BY PLOWING METHOD.                                       |                      |                                       |                     |                    |          |             |         |           |                           |                       |
| FIELD WORK: SURVEYING, SKETCH PLANS.                                                                     |                      |                                       |                     |                    |          |             |         |           |                           |                       |
| DRAFTING: CAD DRAWINGS OF PROPOSED INSTALLATION, AS-BUILT DRAWINGS.                                      |                      |                                       |                     |                    |          |             |         |           |                           |                       |
| TECHNICAL: SPLICE AND TEST FIBER CABLE.                                                                  |                      |                                       |                     |                    |          |             |         |           |                           |                       |
| ENGINEERING: ROUTE PLANNING, SUPERVISION OF CONSTRUCTION & TECHNICAL CREWS, SCHEDULING, SOME ROW ISSUES. |                      |                                       |                     |                    |          |             |         |           |                           |                       |
| OTHER: ROW ACQUISITION, LEGAL, ADMINISTRATION                                                            |                      |                                       |                     |                    |          |             |         |           |                           |                       |
| MATERIALS:                                                                                               |                      |                                       |                     |                    |          |             |         |           |                           |                       |
| CABLE:                                                                                                   |                      | \$1.00/FT (12-F, SINGLEMODE, ARMORED) |                     |                    |          | \$5,280     |         |           |                           |                       |
| MANHOLES:                                                                                                |                      | 3/MILE @ \$700/EA                     |                     |                    |          | \$2,100     |         |           |                           |                       |
| WARNING TAPE:                                                                                            |                      | \$0.05/FT                             |                     |                    |          | \$264       |         |           |                           |                       |
| WARNING SIGNS:                                                                                           |                      | 1/500' @ \$50/EA                      |                     |                    |          | \$528       |         |           |                           |                       |
| SPlicing:                                                                                                |                      | 1 SPLICE/MILE @ \$1000                |                     |                    |          | \$1,000     |         |           |                           |                       |
| MISC.                                                                                                    |                      |                                       |                     |                    |          | \$500       |         |           |                           |                       |
| TOTAL                                                                                                    |                      |                                       |                     |                    |          | \$9,672     |         |           |                           |                       |

# FIBER OPTIC AND VIDEO EQUIPMENT INSTALLATION COSTS

| URBAN AREAS                                                                                   |                      | CONSULTATION COSTS                           |                               |            |          |             |         |           | TOTAL               | TOTAL           |
|-----------------------------------------------------------------------------------------------|----------------------|----------------------------------------------|-------------------------------|------------|----------|-------------|---------|-----------|---------------------|-----------------|
| DISTANCE MI                                                                                   | CONSTRUCTION COST/FT | CONSTRUCTION COST/MI                         | CONSTR <sup>N</sup> TECHNICAL | FIELD WORK | DRAFTING | ENGINEERING | OTHER   | MATERIALS | ESTIMATED COST/MILE | ESTIMATED COSTS |
| 1                                                                                             | \$4.00               | \$21,120                                     | \$1,500                       | \$1,800    | \$1,200  | \$2,500     | \$2,000 | \$15,712  | \$45,832            | \$45,832        |
| 5                                                                                             | \$3.00               | \$15,840                                     | \$1,500                       | \$1,800    | \$1,200  | \$2,500     | \$2,000 | \$15,712  | \$40,552            | \$202,760       |
| CONSTRUCTION: PLACE 2" PVC DUCT @ 36" DEPTH; PULL CABLE THROUGH DUCT.                         |                      |                                              |                               |            |          |             |         |           |                     |                 |
| MATERIALS:                                                                                    |                      | CABLE: \$1.00/FT (12-F, SINGLEMODE, ARMORED) |                               |            |          | \$5,280     |         |           |                     |                 |
|                                                                                               |                      | DUCT: \$0.50/FT (2" PVC)                     |                               |            |          | \$2,640     |         |           |                     |                 |
|                                                                                               |                      | MANHOLES: 5/MILE @ \$700/EA                  |                               |            |          | \$3,500     |         |           |                     |                 |
|                                                                                               |                      | WARNING TAPE: \$0.05/FT                      |                               |            |          | \$264       |         |           |                     |                 |
|                                                                                               |                      | WARNING SIGNS: 1/500' @ \$50/EA              |                               |            |          | \$528       |         |           |                     |                 |
|                                                                                               |                      | SPlicing: 2 SPLICE/MILE @ \$1000             |                               |            |          | \$2,000     |         |           |                     |                 |
|                                                                                               |                      | MISC.                                        |                               |            |          | \$1,500     |         |           |                     |                 |
|                                                                                               |                      | TOTAL                                        |                               |            |          | \$15,712    |         |           |                     |                 |
| END EQUIPMENT COSTS                                                                           |                      |                                              |                               |            |          |             |         |           |                     |                 |
|                                                                                               |                      | LOW                                          |                               | HIGH       |          |             |         |           |                     |                 |
| EQUIPMENT COST/END:                                                                           |                      | \$20,000                                     |                               | -          |          | \$50,000    |         |           |                     |                 |
| INSTALLATION LABOR:                                                                           |                      | \$5,000                                      |                               | -          |          | \$7,500     |         |           |                     |                 |
| TOTAL ESTIMATED COSTS/END:                                                                    |                      | \$25,000                                     |                               | -          |          | \$57,500    |         |           |                     |                 |
| RANGE OF LOW - HIGH COSTS ARE DETERMINED BY INDUSTRY SPECIFICATIONS FOR SPECIFIC APPLICATION. |                      |                                              |                               |            |          |             |         |           |                     |                 |
| EQUIPMENT COSTS INCLUDE THE FOLLOWING:                                                        |                      |                                              |                               |            |          |             |         |           |                     |                 |
| • FIBER OPTIC MULTIPLEXER                                                                     |                      |                                              |                               |            |          |             |         |           |                     |                 |
| • VIDEO CODEC EQUIPMENT                                                                       |                      |                                              |                               |            |          |             |         |           |                     |                 |
| • RACKING HARDWARE                                                                            |                      |                                              |                               |            |          |             |         |           |                     |                 |
| • FIBER TERMINATION HARDWARE                                                                  |                      |                                              |                               |            |          |             |         |           |                     |                 |
| • CROSS CONNECT HARDWARE                                                                      |                      |                                              |                               |            |          |             |         |           |                     |                 |
| • POWER SUPPLY SYSTEM                                                                         |                      |                                              |                               |            |          |             |         |           |                     |                 |
| • MISCELLANEOUS CABLES                                                                        |                      |                                              |                               |            |          |             |         |           |                     |                 |
| MAINTENANCE                                                                                   |                      |                                              |                               |            |          |             |         |           |                     |                 |
| ESTIMATED COSTS FOR MAINTENANCE AGREEMENT: \$3300 - \$7600/YEAR/END                           |                      |                                              |                               |            |          |             |         |           |                     |                 |
| (MAINTENANCE ON END EQUIPMENT)                                                                |                      |                                              |                               |            |          |             |         |           |                     |                 |

## APPENDIX E - Cost Estimates For Microwave Systems

**DIGITAL RADIO SYSTEM  
BASIC SYSTEM DUPLEX (Non-Protected)**

**SHORT HAUL 3 MILES**

| <b>Equipment</b>                                              | <b>Unit Price</b> | <b>Point<br/>A</b> | <b>Point<br/>B</b> | <b>Point<br/>C</b> | <b>System<br/>Total</b> |
|---------------------------------------------------------------|-------------------|--------------------|--------------------|--------------------|-------------------------|
| Transmitter/Receiver<br>w/ battery unit<br>Antenna (included) | \$10,300          | 1                  | 1                  |                    | \$20,600                |
| Cable                                                         | 600               | 1                  | 1                  |                    | 1,200                   |
| Audio Subcarrier                                              | 930               | 1                  | 1                  |                    | 1,860                   |
| Tower                                                         | 3,000             | 1                  | 1                  |                    | 6,000                   |
| Path Study                                                    | 1,000             | 1                  | 1                  |                    | 2,000                   |
| Installation/Test                                             | 1,500             | 1                  | 1                  |                    | <u>3,000</u>            |
|                                                               |                   |                    |                    |                    | \$34,660                |

TERMS USED ON THE FOLLOWING PRICE LISTS ARE DEFINED BELOW:

Duplex refers to two-way communication.

Audio subcarrier refers to equipment to put audio on video channel.

Waveguide refers to antenna feed from antenna to transmitter.

Dehydrator refers to unit that keeps the waveguide moisture free.

Charger system refers to the battery power unit.

High power (TWT) and the auto power control refers to a power amplifier unit.

Non-Protected refers to equipment that does NOT supply automatic redundancy to cover system failures.

**DIGITAL RADIO SYSTEM  
BASIC SYSTEM DUPLEX (Non-Protected)**

**SHORT HAUL 10 MILES**

| Equipment            | Unit Price | Point<br>A | Point<br>B | Point<br>C | System<br>Total |
|----------------------|------------|------------|------------|------------|-----------------|
| Transmitter/Receiver | \$10,300   | 1          | 1          |            | \$20,600        |
| Antenna 4 feet       | 1,500      | 1          | 1          |            | 3,000           |
| Ant Cable            | 600        | 1          | 1          |            | 1,200           |
| Tower                | 5,000      | 1          | 1          |            | 10,000          |
| Path Study           | 1,000      | 1          | 1          |            | 2,000           |
| Installation/Test    | 2,000      | 1          | 1          |            | <u>4,000</u>    |
|                      |            |            |            |            | \$40,800        |

This system includes a heavier extension tower on the building roof that extends to at least 100 feet. The antenna size is increased over the 3 mile distance antenna adding an additional \$1,500 to the cost.

**DIGITAL RADIO SYSTEM (1 DS3 CAPACITY)  
BASIC SYSTEM DUPLEX (Non-Protected)**

**SINGLE HOP 20 MILES**

| Equipment              | Unit Price | Point<br>A | Point<br>B | Point<br>C | System<br>Total |
|------------------------|------------|------------|------------|------------|-----------------|
| Transmitter/Receiver   | \$32,720   | 1          | 1          |            | \$65,440        |
| Antenna 8 foot         | 3,200      | 1          | 1          |            | 6,400           |
| Waveguide (per foot)   | 13         | 250        | 250        |            | 6,500           |
| Ant/WG Hardware        | 2,500      | 1          | 1          |            | 5,000           |
| Dehydrator             | 756        | 1          | 1          |            | 1,512           |
| Charger System 12 Amps | 2,095      | 1          | 1          |            | 4,190           |
| Batteries 96 Amp Hour  | 937        | 1          | 1          |            | 1,874           |
| Tower 200 foot         | 20,000     | 1          | 1          |            | 40,000          |
| Path Study             | 1,500      |            |            |            | 3,000           |
| Installation/Test      | 16,000     | 1          | 1          |            | <u>32,000</u>   |
|                        |            |            |            |            | \$165,916       |

**DIGITAL RADIO SYSTEM (1 DS3 CAPACITY)  
BASIC SYSTEM DUPLEX (Non-Protected)**

**SINGLE HOP 30 MILES**

| <b>Equipment</b>       | <b>Unit Price</b> | <b>Point<br/>A</b> | <b>Point<br/>B</b> | <b>Point<br/>C</b> | <b>System<br/>Total</b> |
|------------------------|-------------------|--------------------|--------------------|--------------------|-------------------------|
| Transmitter/Receiver   | \$32,720          | 1                  | 1                  |                    | \$65,440                |
| High Power (TWT)       | 4,000             | 1                  | 1                  |                    | 8,000                   |
| Auto Power Control     | 1,550             | 1                  | 1                  |                    | 3,100                   |
| Antenna 8 foot         | 3,200             | 1                  | 1                  |                    | 6,400                   |
| Waveguide (per foot)   | 13                | 320                | 320                |                    | 8,320                   |
| Ant/WG Hardware        | 2,554             | 1                  | 1                  |                    | 5,108                   |
| Dehydrator             | 850               | 1                  | 1                  |                    | 1,700                   |
| Charger System 25 Amps | 3,700             | 1                  | 1                  |                    | 7,400                   |
| Batteries 200 Amp Hour | 1,500             | 1                  | 1                  |                    | 3,000                   |
| Tower 300 foot         | 35,000            | 1                  | 1                  |                    | 70,000                  |
| Path study             | 1,500             |                    |                    |                    | 3,000                   |
| Installation/Test      | 16,000            | 1                  | 1                  |                    | <u>32,000</u>           |
|                        |                   |                    |                    |                    | * \$213,468             |

**DIGITAL RADIO SYSTEM (1 DS3 CAPACITY)  
BASIC SYSTEM DUPLEX (Non-Protected)**

**TWO HOP 50 MILES  
20 mile hop & 30 mile hop**

| <b>Equipment</b>         | <b>Unit Price</b> | <b>Point<br/>A</b> | <b>Point<br/>B</b> | <b>Point<br/>C</b> | <b>System<br/>Total</b> |
|--------------------------|-------------------|--------------------|--------------------|--------------------|-------------------------|
| Transmitter/Receiver     | \$32,720          | 1                  | 2                  | 1                  | \$130,800               |
| High Power (TWT)         | 4,000             |                    | 1                  | 1                  | 8,000                   |
| Auto Power Control (APC) | 1,550             |                    | 1                  | 1                  | 3,100                   |
| Antenna 6 foot           | 1,529             | 1                  | 1                  |                    | 3,058                   |
| Antenna 8 foot           | 3,200             |                    | 1                  | 1                  | 6,400                   |
| Waveguide (WG) per foot  | 13                | 320                | 640                | 320                | 16,000                  |
| Ant/WG Hardware          | 2,554             | 1                  | 2                  | 1                  | 10,216                  |
| Dehydrator               | 756               | 1                  |                    | 1                  | 1,512                   |
| Dehydrator               | 850               |                    | 1                  |                    | 850                     |
| Charger System 12 Amps   | 2,095             | 1                  |                    | 1                  | 4,190                   |
| Charger System 25 Amps   | 3,700             |                    | 1                  |                    | 3,700                   |
| Batteries 96 Amp Hour    | 937               | 1                  |                    | 1                  | 1,874                   |
| Batteries 200 Amp Hour   | 1,500             |                    | 1                  |                    | 1,500                   |
| Tower 300 foot           | 35,000            | 1                  | 1                  | 1                  | 105,000                 |
| Path study               | 1,500             |                    |                    |                    | 4,500                   |
| Installation/Test        | 16,000            | 1                  |                    | 1                  | 32,000                  |
| Installation/Test        | 24,000            |                    | 1                  |                    | <u>24,000</u>           |
|                          |                   |                    |                    |                    | <b>\$356,700</b>        |

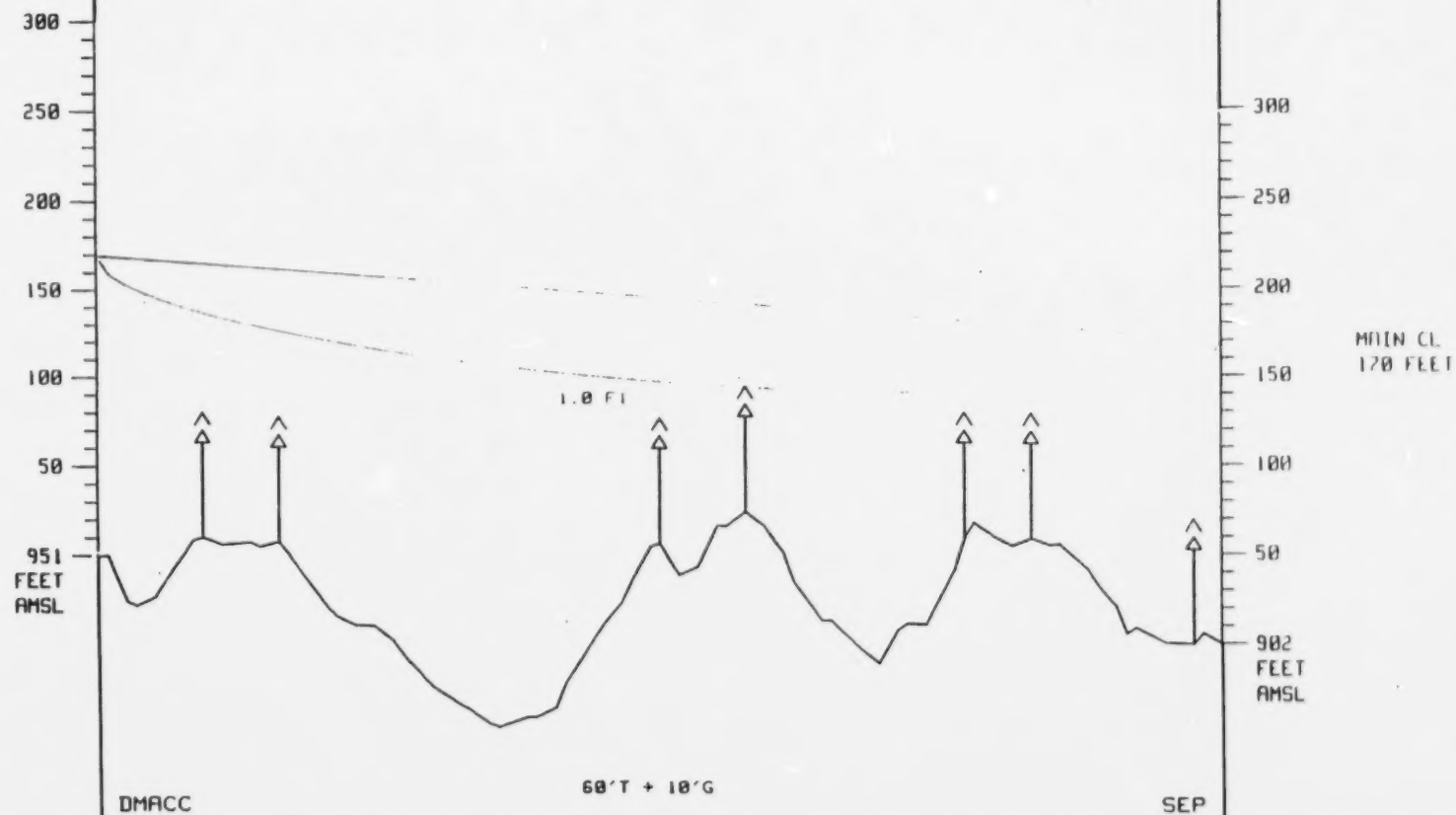
**DIGITAL RADIO SYSTEM (1 DS3 CAPACITY)  
BASIC SYSTEM DUPLEX (Non-Protected)**

**FOUR HOP 75 MILES  
25 mile hops**

| <b>Equipment</b>       | <b>Unit Price</b> | <b>Point<br/>A</b> | <b>Point<br/>B</b> | <b>Point<br/>C</b> | <b>Point<br/>D</b> | <b>System<br/>Total</b> |
|------------------------|-------------------|--------------------|--------------------|--------------------|--------------------|-------------------------|
| Transmitter/Receiver   | \$32,720          | 1                  | 2                  | 2                  | 1                  | \$196,320               |
| High Power (TWT)       | 4,000             | 1                  | 1                  | 1                  | 1                  | 16,000                  |
| Auto Power Control     | 1,550             | 1                  | 1                  | 1                  | 1                  | 6,200                   |
| Antenna 6 foot         | 1,529             | 1                  | 2                  | 2                  | 1                  | 9,174                   |
| Waveguide (WG)per foot | 13                | 280                | 560                | 560                | 280                | 21,840                  |
| Ant/WG Hardware        | 2,700             | 1                  | 2                  | 2                  | 1                  | 16,200                  |
| Dehydrator             | 850               | 1                  | 1                  | 1                  | 1                  | 3,400                   |
| Charger System 12 Amps | 2,095             | 1                  |                    |                    | 1                  | 4,190                   |
| Charger System 25 Amps | 3,700             |                    | 1                  | 1                  |                    | 7,400                   |
| Batteries 96 Amp Hour  | 937               | 1                  |                    |                    | 1                  | 1,874                   |
| Batteries 200 Amp Hour | 1,500             |                    | 1                  | 1                  |                    | 3,000                   |
| Tower 250 feet         | 30,000            | 1                  | 1                  | 1                  | 1                  | 120,000                 |
| Path Study             | 1,500             |                    |                    |                    |                    | 7,500                   |
| Installation/Test      | 16,000            | 1                  |                    |                    | 1                  | 32,000                  |
| Installation/Test      | 24,000            |                    | 1                  | 1                  |                    | <u>48,000</u>           |
|                        |                   |                    |                    |                    |                    | <b>\$493,098</b>        |

## APPENDIX F - Sample Microwave Path Studies and Profiles

PATH ROUGHNESS IS 35 FEET FROM 0 TO 11.8 MILES



41-42-29.0 N  
93-36-47.0 W

AZIMUTH: 129.8

F = 6.725 GHZ

DISTANCE IN MILES

D = 11.80 MI

41-35-55.0 N  
93-26-17.0 W

AZIMUTH: 309.9

— GROUND ELEVATION OF PROFILE  
— DOTTED LINE = 1ST FRESNEL ZONE  
— MAIN CENTERLINE/EVEN FRESNEL  
— DIVERSITY CL/ODD FRESNEL  
++ TERRAIN OVER WATER  
— OBSTRUCTION OFF PATH

PATH PROFILE  
DATA FROM: USGS 3-SEC DATA  
DRAWN BY:  
K-4/3

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|                                               |                                |                 |
|-----------------------------------------------|--------------------------------|-----------------|
| Analog / Digital (A/D)                        | D                              |                 |
| Path Name                                     | PATH 1                         |                 |
| Radio - Configuration - FCC #                 | ULTRASTAR 6-45M                |                 |
| Site Name                                     | DMACC                          | SEP             |
| Latitude                                      | 93° 36' 47.0" N                | 93° 26' 17.0" N |
| Longitude                                     | 41° 42' 29.0" W                | 41° 35' 55.0" W |
| Ground Elevation (ft)                         | 950                            | 925             |
| Structure Height (ft)                         | 0                              | 0               |
| Tower Height (ft)                             | 100                            | 100             |
| Antenna C.L. (ft)                             | 70                             | 70              |
| Azimuth                                       | 2.1°                           | 182.3°          |
| Tilt                                          | 0.11°                          | 0.07°           |
| Path Length (miles)                           |                                | 11.79           |
| Frequency (GHz)                               |                                | 6.700           |
| Free Space Loss (dB)                          |                                | 134.53          |
| Atmospheric Absorption (dB)                   |                                | 0.23            |
| Alignment Factor (dB)                         |                                | 2.00            |
| Path Loss (dB)                                |                                | 136.76          |
|                                               | Tx / Rx Antenna System         |                 |
| Antenna Diameter (ft)                         | 6.00                           | 6.00            |
| Antenna Polarization (V/H)                    | V                              | V               |
| Antenna Gain (dBi)                            | 39.58                          | 39.58           |
| Radome Loss (dB)                              | 0.00                           | 0.00            |
| Line Loss (dB/100 ft)                         | 1.36                           | 1.36            |
| Line Length (ft)                              | 80                             | 80              |
| Total Line Loss (dB)                          | 1.09                           | 1.09            |
| Ant. Jumper (dB)                              | 0.20                           | 0.20            |
| Common Attenuator (dB)                        | 0.00                           | 0.00            |
| Antenna System Gain (dB)                      | 38.30                          | 38.30           |
|                                               | Transmitter                    |                 |
| Transmitter Power (dBm)                       | 30.00                          | 30.00           |
| Tx Attenuator (dB)                            | 0.00                           | 0.00            |
| ERP (dB)                                      | 68.30                          | 68.30           |
| Max FCC ERP (dB)                              | N/A                            | N/A             |
|                                               | Receiver                       |                 |
| Rcv Carrier (dBm)**                           | -30.16                         | -30.16          |
| Receiver Sensitivity (dBm)                    | -69.00                         | -69.00          |
| Flat Fade Margin (dB)                         | 38.84                          | 38.84           |
| Dispersive Fade Margin (dB)                   | 41.00                          | 41.00           |
| Composite Fade Margin (dB)                    | 36.77                          | 36.77           |
|                                               | Diversity Receiver             |                 |
| Div Antenna Spacing (ft)                      |                                |                 |
| Div Antenna Size (ft)                         |                                |                 |
| Div Antenna Gain (dBi)                        |                                |                 |
| Radome Loss (dB)                              |                                |                 |
| Total Line Loss at Div. Recv (dB)             |                                |                 |
| Rcv Ant. Jumper (dB)                          |                                |                 |
| Div Rcv Carrier (dBm)                         |                                |                 |
| Div Flat Fade Margin (dB)                     |                                |                 |
| Div Composite Fade Marg. (dB)                 |                                |                 |
| Div Improvement Factor                        | 1.00                           | 1.00            |
|                                               | Multipath Outage               |                 |
| Coastal, Average, Dry (2, 1, 0.5)             | 1                              |                 |
| Roughness Factor (20 ft ≤ ΔH ≤ 140 ft)        | 70                             |                 |
| Average Temperature (35 °F ≤ T ≤ 75 °F)       | 50                             |                 |
| Terrain Factor (a) (4, 1, 0.25)               | 0.65                           |                 |
| Climatic Factor (b) (.5, .25, .125)           | 0.25                           |                 |
| Probability of Multipath Outage               | 9.31E-07                       |                 |
| Multipath Outage (sec/yr)                     | 29.45                          |                 |
|                                               | Rain Outage                    |                 |
| Rain Rate (.01 % of time) mm/hr               | 95.00                          |                 |
| Probability of Rain Outage                    | 0.00E+00                       |                 |
| Rain Outage (sec/yr)                          | 0.00 sec                       |                 |
|                                               | Total Rain & Multipath Outages |                 |
| Outage (severely errored) time per year (sec) | 29.45 sec                      |                 |
| Percentage Availability***                    | 99.999907                      |                 |

\*\*Calculated Received Carrier Level is Based on Free Space Loss\*\*

\*\*\*Predicted Availability is Based on Statistical Analysis and Cannot be Guaranteed for any Specific Time Period\*\*\*

# PATH CALCULATIONS

SYSTEM:

ROUTE:

FILE:

| SITE NAME                |         | GARNAVILLO   |            | ELKADER   |           |
|--------------------------|---------|--------------|------------|-----------|-----------|
| MAIN ANTENNA SIZE        | Feet    | 6.0          | P6-65D     | 6.0       | P6-65D    |
| MAIN ANTENNA GAIN        | dBi     | 39.8         |            | 39.8      |           |
| MAIN CENTERLINE          | Feet    | 290.0        |            | 290.0     |           |
| FEEDER LENGTH            | Feet    | 320.0        |            | 320.0     |           |
| FEEDER LOSS PER 100 FT   | dB      | 1.4          | EW-63      | 1.4       | EW-63     |
| FEEDER LOSS              | dB      | 4.4          |            | 4.4       |           |
| RADOME LOSS              | dB      | .5           |            | .5        |           |
| CIRCULATOR LOSS          | dB      | 0.0          |            | 0.0       |           |
| OTHER TRANSMIT LOSSES    | dB      | 4.0          | *          | 4.0       | *         |
| OTHER RECEIVE LOSSES     | dB      | 0.0          |            | 0.0       |           |
| CALCULATED EIRP          | dBm     | 57.9         |            | 57.9      |           |
| MAXIMUM ALLOWED EIRP     | dBm     | 58.6         |            | 58.6      |           |
| RADIO EQUIPMENT TYPE     |         | MDR-4106U NS |            |           |           |
| FREQUENCY BAND           | MHz     | 6725         |            |           |           |
| PATH LENGTH              | Miles   | 9.0          |            |           |           |
| MEAN ANNUAL TEMPERATURE  | Deg F   | 48.7         |            |           |           |
| ABSOLUTE HUMIDITY        | g/m^3   | 14.0         |            |           |           |
| CLIMATE FACTOR           |         | 1.0          |            |           |           |
| ROUGHNESS FACTOR         | Feet    | 65.0         |            |           |           |
| FREE SPACE LOSS          | dB      | 132.2        |            |           |           |
| ABSORPTION LOSS          | dB      | .2           |            |           |           |
| FIELD MARGIN             | dB      | 1.0          |            |           |           |
| DISPERSIVE FADE MARGIN   | dB      | 56.0         |            |           |           |
| TRANSMIT POWER           | dBm     | 27.0         |            |           |           |
| APC POWER REDUCTION      | dB      | 0.0          |            |           |           |
| MAXIMUM RECEIVED SIGNAL  | dBm     | -18.5        |            |           |           |
| RECEIVER THRESHOLD       | dBm     | -73.5        |            |           |           |
|                          |         | BER= 10-6    |            |           |           |
| MAIN RECEIVED SIGNAL     | dBm     | -40.5        |            | -40.5     |           |
| THERMAL FADE MARGIN      | dB      | 33.0         |            | 33.0      |           |
| EXTERNAL INTERFERENCE FM | dB      | 43.0         | T= -73.5   | 43.0      | T/I= 34.0 |
| NUMBER OF EXPOSURES      | dB      | 1.0          | I= -107.5  | 1.0       | C/I= 24.0 |
| TOTAL EXTERNAL INT FM    | dB      | 43.0         |            | 43.0      |           |
| FLAT FADE MARGIN         | dB      | 32.6         |            | 32.6      |           |
| FREQ DIV IMPROVE FACTOR  | THERMAL | 1.0          |            | 1.0       |           |
| SPACE DIV IMPROVE FACTOR | THERMAL | 1.0          |            | 1.0       |           |
| MULTIPATH OUTAGE SECONDS | THERMAL | 37.7         |            | 37.7      |           |
| FREQ DIV IMPROVE FACTOR  | DIGITAL | 1.0          |            | 1.0       |           |
| SPACE DIV IMPROVE FACTOR | DIGITAL | 1.0          |            | 1.0       |           |
| MULTIPATH OUTAGE SECONDS | DIGITAL | .2           |            | .2        |           |
| TOTAL MULTIPATH          | 2-WAY   | seconds      | 75.8       |           |           |
| UPFADE OUTAGE            | 2-WAY   | seconds      | 0.0        |           |           |
| PATH AVAILABILITY        | 2-WAY   | percent      | 99.9997598 | 75.8 sec  |           |
| OUTAGE OBJECTIVE         | YEAR    | percent      | 99.9990000 | 315.4 sec |           |

\* ATTENUATED TO MEET FCC MAX EIRP

APPENDIX G - Cost Estimates For Compressed Video Systems

4



The prices listed herein are not discounted.  
Ordering offices must apply discount of 18%.

---

|               |                                                                                                                                                                                                                                                 |                 |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| <b>BK125</b>  | MediaConferencing System with MediaMax 386, Pan Tilt Zoom Camera and controller, document camera, Pen Pal Graphics, hand-held remote control and detector, two microphones, speaker, one 25" monitor, PIP, and Benchmark 125 enclosure          | <b>\$67,000</b> |
| <b>BK220</b>  | MediaConferencing System with MediaMax 386, Pan Tilt Zoom Camera and controller, document camera, Pen Pal Graphics, hand-held remote control and detector, two microphones, speaker, two 20" monitors, and Benchmark 220 enclosure              | <b>\$68,000</b> |
| <b>BK225</b>  | MediaConferencing System with MediaMax 386, Pan Tilt Zoom Camera and controller, document camera, Pen Pal Graphics, hand-held remote control and detector, two microphones, speaker, two 25" monitors, and Benchmark 225 enclosure              | <b>\$72,000</b> |
| <b>BK235</b>  | MediaConferencing System with MediaMax 386, Pan Tilt Zoom Camera and controller, document camera, Pen Pal Graphics, hand-held remote control and detector, two microphones, speaker, two 35" monitors, and Benchmark 235 enclosure              | <b>\$85,000</b> |
| <b>MM-FD1</b> | MediaConferencing System with MediaMax 386, Pan Tilt Zoom Camera and controller, document camera, Pen Pal Graphics, hand-held remote control and detector, two microphones, speaker, and two 13" monitors in a ready-to-ship hardened enclosure | <b>\$75,000</b> |

Information supplied as part of the bid response for the  
compressed video classroom

**BK 125 SYSTEM**

Codec = \$37,892  
Equipment = \$29,108

List price for equipment from Appendix J

|             |                          |
|-------------|--------------------------|
| Camera      | \$2,270                  |
| Elmo        | \$3,100                  |
| Microphones | \$420                    |
| Speaker     | \$163                    |
| Monitor     | \$1,590                  |
| Pen Pal     | \$7,000                  |
| Enclosure   | \$2,000 (Brackets \$677) |

Total \$16,543 = 43% less by individual purchase

ALL COMPONENTS HAVE A ONE YEAR WARRANTY.

# GALLERY VIDEOCONFERENCING SYSTEM

| <u>ITEM</u> | <u>DESCRIPTION</u>                                                                                                                                                                                                                                                                                       | <u>PRICE</u> |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| Gallery 125 | Roll-about videoconference room system includes front camera with pan/tilt/zoom/focus capability; one 25-inch NTSC color monitor; control system with table-top control panel; complete audio system with Voicecrafter™ digital echo cancellation and two microphones, and modem for remote diagnostics. | \$25,000     |
|             | Codec = \$36,195                                                                                                                                                                                                                                                                                         |              |
|             | Equipment = \$25,000                                                                                                                                                                                                                                                                                     |              |
|             | List price for equipment from Appendix J                                                                                                                                                                                                                                                                 |              |
|             | Camera \$2,270                                                                                                                                                                                                                                                                                           |              |
|             | Microphones \$ 420                                                                                                                                                                                                                                                                                       |              |
|             | Speaker \$ 163                                                                                                                                                                                                                                                                                           |              |
|             | Monitor \$1,590                                                                                                                                                                                                                                                                                          |              |
|             | Control \$2,000                                                                                                                                                                                                                                                                                          |              |
|             | Enclosure \$2,000 (Brackets \$677)                                                                                                                                                                                                                                                                       |              |
|             | Mixer \$2,800                                                                                                                                                                                                                                                                                            |              |
|             | Echo cancel \$1,640                                                                                                                                                                                                                                                                                      |              |
|             | Total \$12,883 = 48% less by individual purchase                                                                                                                                                                                                                                                         |              |

|             |                                                                                                                                                                                                                                                                                                                                            |          |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| Gallery 235 | Roll-about videoconference room system includes front camera with pan/tilt/zoom/focus capability; two 35-inch NTSC color monitors; control system with table-top control panel; complete audio system with Voicecrafter™ digital echo cancellation and two microphones; NTSC document camera with stand, and modem for remote diagnostics. | \$41,500 |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|

Information supplied as part of the bid response for the compressed video classroom

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| EQUIPMENT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | QTY. | DISCOUNT<br>PRICE | EXTENDED<br>PRICE |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------------------|-------------------|
| <b>MANDATORY REQUIREMENTS</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |      |                   |                   |
| <b>Visualink 5000 Model 20 Codec (full duplex)</b><br>Px64 Compatibility<br>56Kbps - 2.048Mbps capability<br>3 compression algorithms<br>(CIF, QCIF, NEC High Res.)<br>PIP<br>Encryption<br>3 data ports<br>(2-RS232, 1-RS449)<br>4x3 Video Switcher<br>Choice of Line Interface<br>T1 or Dual RS-449 or Dual V.35<br>Choice of Audio Compression<br>Standard 48/56Kb Audio Compression<br>G.711 (3.4KHz) - A-Law, u-Law<br>G.722 (7 KHz) - SB ADPCM<br>or<br>Proprietary MPC 16Kb including<br>G.711 (3.4KHz) - A-Law, u-Law<br>and ADPCM | 2    | \$32,560          | \$65,120          |
| <b>AEC-400 Acoustic Echo Cancellor</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 2    | \$4,608           | \$9,216           |
| <b>CSU/DSU</b><br>provide a compatible CSU/DSU to interface to the Visualink 5000. There are a wide variety of CSU/DSU's available based on transmission speed and other factors. Once Iowa State University determines it's network requirements, NEC will provide the proper CSU/DSU to meet both NEC's and the University's specifications.                                                                                                                                                                                             | 2    | TBD               | TBD               |
| <b>TOTAL COST FOR REQUIRED EQUIPMENT ==&gt;</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |      | \$37,168          | \$74,336          |

CODEC BID RESPONSE

FOR CODEC EQUIPMENT FOR A  
DISTANCE EDUCATION CLASSROOM

MAY 27, 1992

PROPOSED  
MEDIAMAX BASIC PLATFORM

- Basic MediaMax platform
  - CCITT Standards H.261/H.221
  - TrueTalk Audio System (3.3Khz)
  - Multipoint interoperable
  - User Control tablet with overlay
  - Built-in FAX port
  - RS232 data port
  - 30 Frames/second Kit (software and hardware that permits MediaMax to operate up to 30 fps @ 384 Kbps)

the price of this equipment as mentioned in sections V is \$37,892/codec

**BEST COPY AVAILABLE**

## DISTANCE EDUCATION PROJECT

PRELIMINARY EQUIPMENT SPECIFICATIONS AND COST ESTIMATES

| DESCRIPTION                               | MAKE            | MODEL                   | QTY | UNIT     | SUB      |
|-------------------------------------------|-----------------|-------------------------|-----|----------|----------|
| I. ORIGATION SITE INSTRUCTOR CONSOLE      |                 |                         |     |          |          |
| PROG. SPEAKER                             | ANCHOR          | AN-1000X                | 1   | 300.00   | 300.00   |
| COMPUTER                                  | APPLE MAC II SI | W/NU-VISTA BD           | 1   | 5000.00  | 5000.00  |
| VISUAL PRESENTER                          | ELMO            | EV-308/LU-308           | 1   | 2600.00  | 2600.00  |
| SLIDE TO VIDEO TRANSFER                   | ELMO            | TRV-35G                 | 1   | 2300.00  | 2300.00  |
| VHS PLAYER                                | PANASONIC       | AG-1730                 | 1   | 500.00   | 500.00   |
| VHS RECORDER                              | PANASONIC       | AG-1730                 | 1   | 500.00   | 500.00   |
| REMOTE SITE MONITOR                       | PANASONIC       | PVM-8220 IN DUAL CONFIG | 1   | 1200.00  | 1200.00  |
| LAVALIERE MIC                             | SHURE           | AMS 28                  | 1   | 200.00   | 200.00   |
| BACKUP WIRED MIC                          | SHURE           | AMS 24                  | 1   | 225.00   | 225.00   |
| PREVIEW/PROGRAM MONITOR                   | SONY            | PVM-8220 IN DUAL CONFIG | 1   | 1200.00  | 1200.00  |
| FURNITURE/RACKS                           | WINSTED         |                         | 1   | 1000.00  | 1000.00  |
| FAX MACHINE                               |                 |                         | 1   | 800.00   | 800.00   |
| II. ORIGATION SITE DISTRIBUTION EQUIPMENT |                 |                         |     |          |          |
| CODEC & CONTROLLER                        | ?               |                         | 1   | 35000.00 | 35000.00 |
| ✓AUDIO/VIDEO DIST.AMP                     | ESE             |                         | 1   | 400.00   | 400.00   |
| AUDIO/VIDEO SWITCHER                      | EXTRON OR TECH  |                         | 1   | 1500.00  | 1500.00  |
| REM.CONT. CAMERAS                         | PANASONIC       | WV-D5100                | 2   | 2800.00  | 5600.00  |
| AUDIO MIXER/ALC SYSTEM                    | SHURE           | AMS 4000                | 1   | 1800.00  | 1800.00  |
| III. ORIGATION SITE STUDENT STATIONS      |                 |                         |     |          |          |
| SPEAKERS FOR SONY MCN                     | ANCHOR          | AN-1001                 | 6   | 200.00   | 1200.00  |
| FURNITURE                                 | LUXOR           | ATW-56                  | 3   | 300.00   | 900.00   |
| MICROPHONES                               | SHURE           | AMS 22                  | 8   | 200.00   | 1600.00  |
| VIEWING MONITORS                          | SONY            | PVM-2530                | 3   | 1500.00  | 4500.00  |
| FURNITURE                                 | TABLES          |                         | 8   | 200.00   | 1600.00  |
| IV. REMOTE SITE DISTRIBUTION EQUIPMENT    |                 |                         |     |          |          |
| CODEC & CONTROLLER                        |                 |                         | 1   | 35000.00 | 35000.00 |
| AUDIO/VIDEO DIST.AMP                      | ESE             |                         | 1   | 400.00   | 400.00   |
| AUDIO/VIDEO SWITCHER                      | EXTRON OR TECH  |                         | 1   | 1500.00  | 1500.00  |
| REM.CONT. CAMERAS                         | PANASONIC       | WV-D5100                | 2   | 2800.00  | 5600.00  |
| AUDIO MIXER/ALC SYSTEM                    | SHURE           | AMS 4000                | 1   | 1800.00  | 1800.00  |
| FURNITURE/RACKS                           | WINSTED         |                         | 1   | 1000.00  | 1000.00  |

PRELIMINARY EQUIPMENT REQUIREMENTS FOR THE  
COMPRESSED VIDEO CLASSROOM  
DATA PRESENTED TO THE CLASSROOM STUDY COMMITTEE

| DESCRIPTION                    | MAKE      | MODEL                   | QTY | UNIT    | SUB     |
|--------------------------------|-----------|-------------------------|-----|---------|---------|
| V. REMOTE SITE MONITOR CONSOLE |           |                         |     |         |         |
| FAX MACHINE                    | ?         |                         | 1   | 800.00  | 800.00  |
| VISUAL PRESENTER               | ELMO      | EV-308/LU-308           | 1   | 2500.00 | 2500.00 |
| VHS RECORDER                   | PANASONIC | AG-1730                 | 1   | 500.00  | 500.00  |
| BACKUP WIRED MIC               | SHURE     | AMS 28                  | 1   | 200.00  | 200.00  |
| PREVIEW/PROGRAM MONITOR        | SONY      | PVM-8220 IN DUAL CONFIG | 1   | 1200.00 | 1200.00 |
| REMOTE SITE MONITOR            | SONY      | PVM-8220 IN DUAL CONFIG | 1   | 1200.00 | 1200.00 |
| FURNITURE/RACKS                | WINSTED   |                         | 1   | 1000.00 | 1000.00 |

## VI. REMOTE SITE STUDENT STATIONS

|                       |        |          |   |         |         |
|-----------------------|--------|----------|---|---------|---------|
| FURNITURE             | ?      |          | 8 | 200.00  | 1600.00 |
| SPEAKERS FOR SONY MON | ANCHOR | AN-1001  | 4 | 200.00  | 800.00  |
| VIDEO CARTS           | LUXOR  | ATW-56   | 2 | 300.00  | 600.00  |
| MICROPHONES           | SHURE  | AMS 22   | 8 | 200.00  | 1600.00 |
| VIEWING MONITORS      | SONY   | PVM-2530 | 2 | 1500.00 | 3000.00 |

|                 |  |  |  |              |  |
|-----------------|--|--|--|--------------|--|
| EQUIPMENT TOTAL |  |  |  | \$ 130225.00 |  |
|-----------------|--|--|--|--------------|--|

## VII. INSTALLATION COSTS

|                 |                  |   |         |         |
|-----------------|------------------|---|---------|---------|
| CABLING/CONDUIT | BELDEN & PANDUIT | 1 | 2000.00 | 2000.00 |
| LABOR           |                  |   |         |         |

## VIII. LINE LEASING \*

 IX. SYSTEM MAINTENANCE/SUPERVISION SUPPORT \*  
 MOVING AND SETUP COSTS (\$250/DAY)  
 TROUBLE CALLS FROM ISU TO SITE

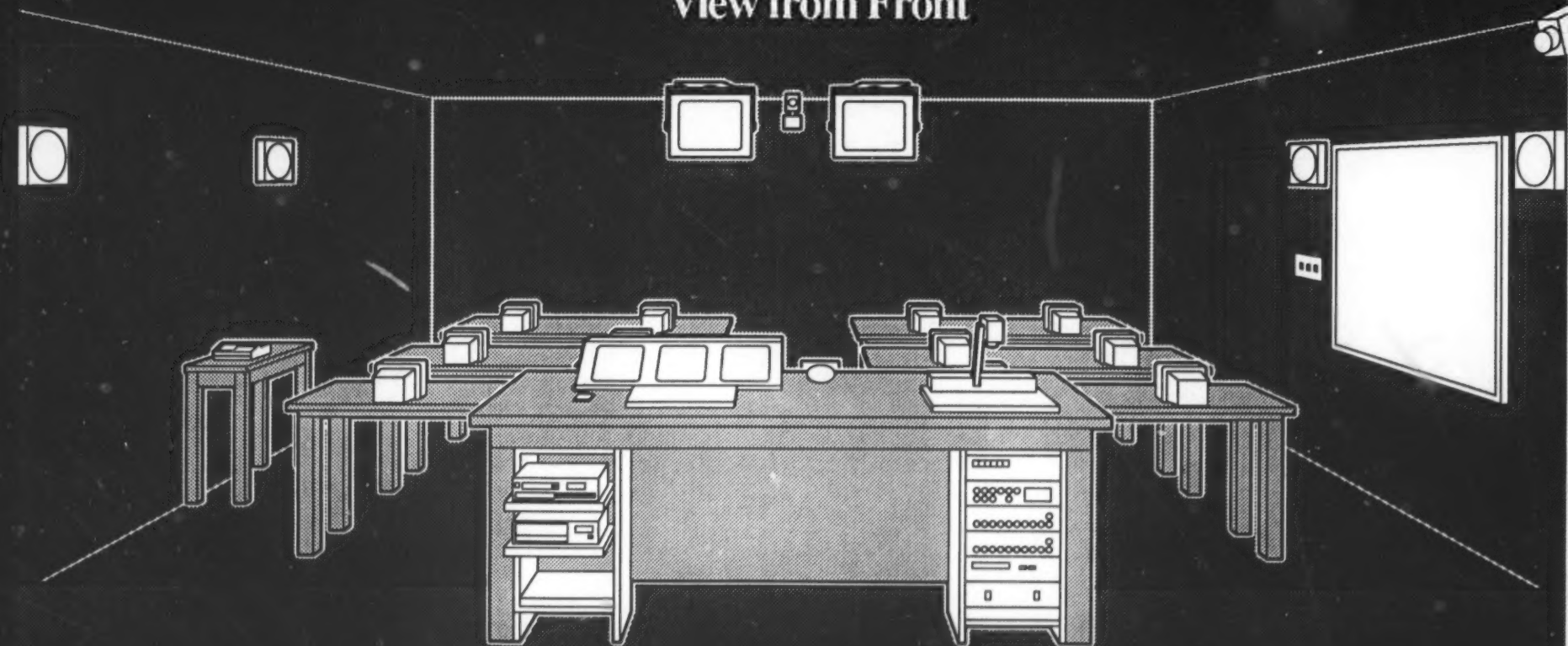
|        |                    |              |
|--------|--------------------|--------------|
| TOTALS | EQUIPMENT          | \$ 130225.00 |
|        | INSTALLATION       | 2000.00      |
|        | LINE LEASING       |              |
|        | SYSTEM MAINTENANCE |              |
|        | TOTAL              |              |

\*ANNUAL ONGOING COSTS

## APPENDIX H - Classroom Designs and Equipment Lists

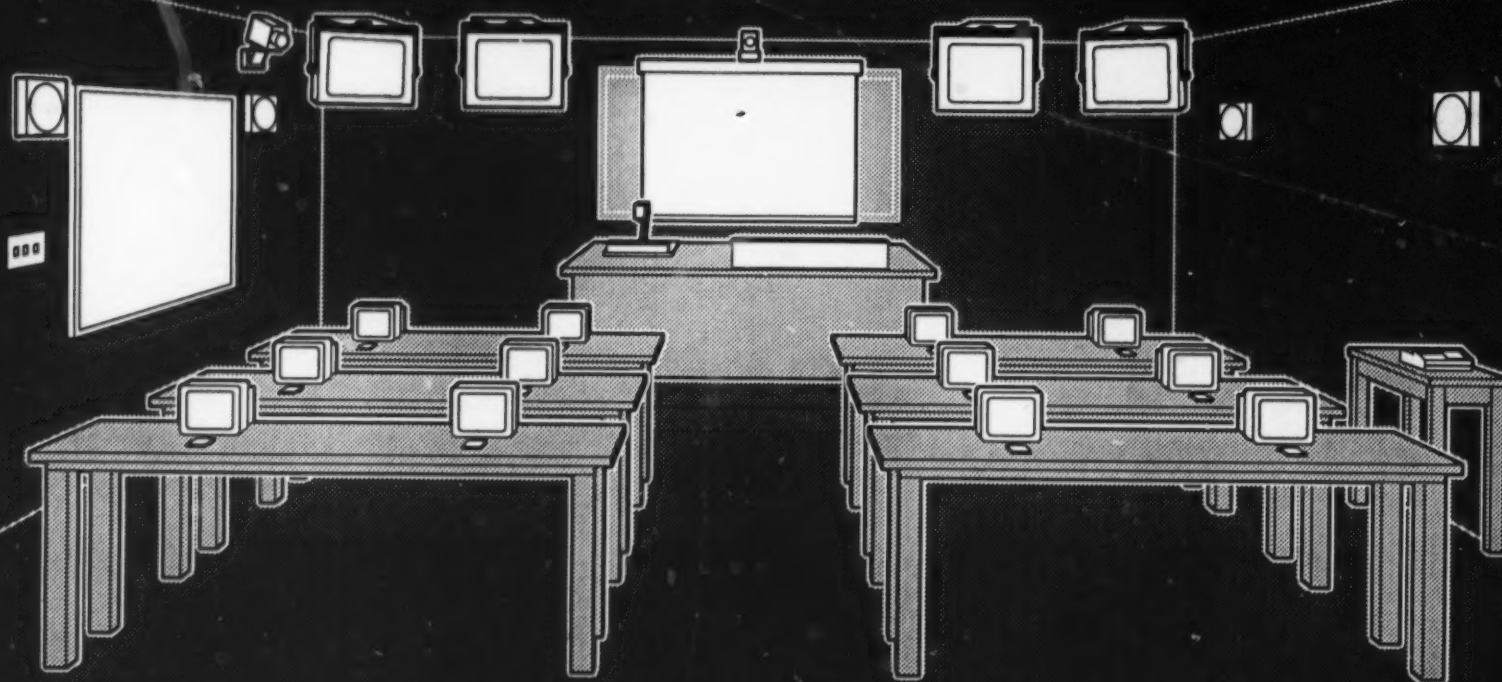
## Distance Learning Classroom - Teaching Site

View from Front



# Distance Learning Classroom - Teaching Site

## View from Rear



Distance Education Classroom Equipment List  
Origination Site

| <u>Cameras</u>                        |                                                            | Quantity | Cost/Unit              | Total Cost     |
|---------------------------------------|------------------------------------------------------------|----------|------------------------|----------------|
| A                                     | Student camera (Panasonic WV-F70)                          | 1        | 4295                   | 4295           |
| B                                     | Student camera                                             | 1        | 4295                   | 4295           |
| C                                     | Teacher camera                                             | 1        | 4295                   | 4295           |
|                                       | Mounting brackets camera (Pan WV131P)                      | 3        | 52                     | 156            |
| D                                     | Visual presenter (Elmo EV-308)                             | 1        | 3100                   | 3100           |
|                                       | lightbar (Elmo LU-308)                                     | 1        | 300                    | 300            |
| <u>Monitors</u>                       |                                                            |          |                        |                |
| E                                     | Monitor, outgoing 25"(Sony PVM2530)                        | 2        | 1590                   | 3180           |
| F                                     | Monitor, remote site 25"                                   | 2        | 1590                   | 3180           |
| G                                     | Teacher monitor, remote site 25"                           | 1        | 1590                   | 1590           |
| H                                     | Teacher monitor, outgoing 25"                              | 1        | 1590                   | 1590           |
| I                                     | Monitor, individual student 12"<br>(NEC PM1271A)           | 12       | 525                    | 6300           |
| J                                     | Monitor, teacher 7" (Panasonic BT-S701N)                   | 3        | 600                    | 1800           |
|                                       | Mounting brackets monitor (ceiling)<br>(Bretford Mfg TVM1) | 6        | 221                    | 1326           |
| <u>Audio</u>                          |                                                            |          |                        |                |
| K                                     | Speakers (Anchor AN1001)                                   | 4        | 163                    | 652            |
| K2                                    | Teacher speaker (Anchor An1000X)                           | 1        | 324                    | 324            |
|                                       | Brackets (Anchor SB730)                                    | 4        | 43                     | 172            |
| L                                     | Microphone, student (Shure AMS22)                          | 12       | 210                    | 2520           |
| M                                     | Microphone, teacher/wireless<br>(Telex FMR-25TD)           | 1        | 600                    | 600            |
| <u>Teacher station</u>                |                                                            |          |                        |                |
| N                                     | Audio/Video control (Crestron)                             | 1        | 6000                   | 6000           |
| O                                     | Teacher control unit                                       |          |                        |                |
|                                       | Rack mount shelving (Winstead)                             | 1        | 500                    | 500            |
|                                       | Audio mixer (Shure AMS8000)                                | 1        | 2800                   | 2800           |
|                                       | Video distribution (Panasonic WJ300B)                      | 2        | 290                    | 580            |
|                                       | Power strip (Winstead 98700)                               | 1        | 69                     | 69             |
|                                       | Light/dimmer control (AMXM320)                             | 1        | 675                    | 675            |
| P                                     | VCR play/record (Panasonic AG1250)                         | 2        | 350                    | 700            |
| Q                                     | Facsimile (HP200)                                          | 1        | 1200                   | 1200           |
|                                       |                                                            |          | <u>EQUIPMENT TOTAL</u> | <u>\$52199</u> |
|                                       |                                                            |          | - 30 %                 | <u>\$36539</u> |
| Supplies, cabling, wiring, connectors |                                                            |          |                        | 3000           |
|                                       |                                                            |          | <u>TOTAL</u>           | <u>\$39539</u> |

|                                                   | Quantity            | Cost/Unit | Total Cost |
|---------------------------------------------------|---------------------|-----------|------------|
| <u>Options for substitution or enhancement</u>    |                     |           |            |
| 3 chip camera (Panasonic WVF250)                  | 1                   | 7800      |            |
| Tripod for camera (ITE-T30)                       | 1                   | 295       |            |
| Large screen monitor 35" (Sony PVM5310)           | 1                   | 2625      |            |
| Multiscan monitors 13" (Sony GVM-1300)            | 1                   | 1495      |            |
| 20" (Sony GVM-2000)                               | 1                   | 2300      |            |
| 35" (Mitsubishi AM-3501R)                         | 1                   | 6900      |            |
| b&w teacher display monitors 4" (PVM 411)         | 1                   | 1540      |            |
| Metal cart for monitor (Winstead R3353)           | 1                   | 210       |            |
| Lavalier microphone (Shure AMS28)                 | 1                   | 235       |            |
| Room control panel (PenPal USWest)                | 1                   | 7000      |            |
| Slide to video converter (Elmo TRV-35G)           | 1                   | 3215      |            |
| Film to video converter (Elmo TRV-16G)            | 1                   | 4290      |            |
| Echo canceller (Shure)                            | 1                   | 1640      |            |
| Time Base corrector (NOVA 700)                    | 1                   | 2290      |            |
| Computer interface (Micro 386 board)              | 1                   | 2200      |            |
| NTSC Genlock card                                 | 1                   | 2000      |            |
| Video Scan Converter PS 2                         | 1                   | 12995     |            |
| Video Scan Converter MAC                          | 1                   | 9995      |            |
| Table 96" x 24" Barron                            | 1                   | 606       |            |
| Table 18" x 60" Barron                            | 1                   | 483       |            |
| Table 60" x 24" Barron                            | 1                   | 518       |            |
| Porcelain board/metal board 72 x 48 \$6.20 sq.ft. |                     | 149       |            |
| <u>Acoustic treatment</u>                         |                     |           |            |
| Carpet                                            | 14.00 -16.00 sq. yd |           |            |
| Wall panels                                       | 5.60 sq. ft         |           |            |
| Drapes                                            | 6.25 sq. ft         |           |            |
| <u>Riser</u>                                      |                     |           |            |
| Materials 8' x 16'                                | 1                   | 160       |            |
| Materials 8' x 24'                                | 1                   | 240       |            |
| Labor                                             | 1                   | 100       |            |
| Consultation:                                     | \$1,250-\$5,000     |           |            |
| Installation:                                     | \$2,500-\$5,000     |           |            |

Basic Classroom  
Distance Education Classroom Equipment List  
Origination Site

| <u>Cameras</u>                        |                                                           | Quantity | Cost/Unit              | Total Cost     |
|---------------------------------------|-----------------------------------------------------------|----------|------------------------|----------------|
| A                                     | Student camera w/o pan, tilt, zoom                        | 1        | 1720                   | 1720           |
| C                                     | Teacher camera (Panasonic WVD5100)                        | 1        | 2930                   | 2930           |
|                                       | Mounting brackets camera (Pan WV131P)                     | 2        | 52                     | 104            |
|                                       | Teacher camera control                                    | 1        | 400                    | 400            |
| D                                     | Visual presenter (Elmo EV-308)                            | 1        | 3100                   | 3100           |
|                                       | lightbar (Elmo-LU308)                                     | 1        | 300                    | 300            |
| <u>Monitors</u>                       |                                                           |          |                        |                |
| E                                     | Monitor, outgoing 25" (Sony PVM2530)                      | 1        | 1590                   | 1590           |
| F                                     | Monitor, remote site 25"                                  | 1        | 1590                   | 1590           |
| G                                     | Teacher monitor, Remote site 25"                          | 1        | 1590                   | 1590           |
| H                                     | Teacher monitor, Outgoing 25"                             | 1        | 1590                   | 1590           |
|                                       | Mounting brackets monitor (ceiling)<br>(Bretford Mf TVM1) | 4        | 221                    | 884            |
| J                                     | Monitor, teacher 7" (Panasonic BT-S701N)                  | 3        | 600                    | 1800           |
| <u>Audio</u>                          |                                                           |          |                        |                |
| K                                     | Speakers (Anchor AN1001)                                  | 4        | 163                    | 652            |
| K 2                                   | Teacher speaker (Anchor AN1000X)                          | 1        | 324                    | 324            |
|                                       | Brackets (Anchor SB730)                                   | 4        | 43                     | 172            |
| L                                     | Microphone, student (AMS22)                               | 12       | 210                    | 2520           |
| M                                     | Microphone, teacher/lavalier (ShureAMS28)                 | 1        | 235                    | 235            |
| <u>Teacher station</u>                |                                                           |          |                        |                |
| N                                     | Audio/Video control (Extron Model 8)                      | 1        | 1495                   | 1495           |
| O                                     | Teacher control unit                                      |          |                        |                |
|                                       | Rack mount shelf (Winstead)                               | 1        | 500                    | 500            |
|                                       | Video dist.(Panasonic WJ300B)                             | 1        | 290                    | 290            |
|                                       | Audio mixer (Shure AMS8000)                               | 1        | 2800                   | 2800           |
|                                       | Power strip (Winstead 98700)                              | 1        | 69                     | 69             |
| P                                     | VCR play/record (Panasonic AG1250)                        | 2        | 350                    | 700            |
| Q                                     | Facsimile (HP200)                                         | 1        | 1200                   | 1200           |
|                                       |                                                           |          | <u>EQUIPMENT TOTAL</u> | <u>\$28555</u> |
|                                       |                                                           |          | - 30%                  | \$19988        |
| Supplies, cabling, wiring, connectors |                                                           |          | \$2,000                | \$21988        |

APPENDIX I - Iowa Narrowcast Advisory Committee Classroom Equipment Specifications

CLASSROOM EQUIPMENT  
SYSTEM TWO

CAMERA EQUIPMENT:

|                                                                                    |        |
|------------------------------------------------------------------------------------|--------|
| CCD 1 chip Cameras with head, ac,<br>lens, tripod head adaptor, and<br>controller. | 12,066 |
|------------------------------------------------------------------------------------|--------|

VIDEO EQUIPMENT:

|                                                                                                                          |       |
|--------------------------------------------------------------------------------------------------------------------------|-------|
| Monitor, mounting brackets, video<br>switcher, synchronizing generator,<br>video amplifier, and associated<br>equipment. | 6,689 |
|--------------------------------------------------------------------------------------------------------------------------|-------|

AUDIO EQUIPMENT:

|                                                                                                                                          |       |
|------------------------------------------------------------------------------------------------------------------------------------------|-------|
| Distribution amplifiers,<br>preamplifiers, power amplifiers,<br>speakers, talk back system,<br>microphones, and associated<br>equipment. | 4,298 |
|------------------------------------------------------------------------------------------------------------------------------------------|-------|

OTHER ASSOCIATED REQUIREMENTS:

|                                                            |       |
|------------------------------------------------------------|-------|
| Podium, cables, connectors,<br>and classroom control unit. | 6,800 |
|------------------------------------------------------------|-------|

Anticipated Discount of 5%

Total

|          |
|----------|
| 29,853   |
| 1,493    |
| \$28,360 |

101790

Minimum equipment list for Iowa Communications Network phase I and II classrooms from the  
Narrowcast Advisory Committee and the Iowa Public Broadcasting Board

CLASSROOM EQUIPMENT  
SYSTEM TWO

| <u>EQUIPMENT</u>                                                                      | <u>UNIT</u> | <u>EXTENDED COST</u> |
|---------------------------------------------------------------------------------------|-------------|----------------------|
| CAMERA EQUIPMENT:                                                                     |             |                      |
| 3- CCD 1 Chip Camera<br>With Head, AC, Lens,<br>Tripod Head Adaptor<br>and Controller | \$3,822     | \$11,466             |
| 1- Copy Stand Camera Mount Power Pole                                                 | 500         | 500                  |
| 2- Camera Wall Mounts                                                                 | 50          | 100                  |
| VIDEO EQUIPMENT:                                                                      |             |                      |
| 3- 27" Color Monitor                                                                  | 1,040       | 3,120                |
| 3- TV Mounting Brackets or TV Stands                                                  | 200         | 600                  |
| 1- 8" Color Monitor                                                                   | 449         | 449                  |
| 1- Rack Mount for 8" Color Monitor                                                    | 200         | 200                  |
| 1- 10X1 Active Video Switcher<br>(Remote Controllable)                                | 995         | 995                  |
| 1- Synchronizing Generator                                                            | 1,005       | 1,005                |
| 1- Video Amplifier                                                                    | 320         | 320                  |
| AUDIO EQUIPMENT:                                                                      |             |                      |
| 2- Audio Distribution Amplifier                                                       | 360         | 720                  |
| 1- Mixer Preamplifier Input                                                           | 398         | 398                  |
| 7- Modules for Mixer Preamplifier                                                     |             | 436                  |
| 1- Mixer Power Amplifier                                                              | 220         | 220                  |
| 4- Speaker Assemblies                                                                 | 43          | 172                  |
| 1- Audio Talk Back System -<br>includes Rack Mount                                    | 1,066       | 1,066                |

|                                  |     |     |
|----------------------------------|-----|-----|
| 10- Student Desk Microphones     | 98  | 980 |
| 1- Teacher's Lavalier Microphone | 306 | 306 |

OTHER ASSOCIATED REQUIREMENTS:

|                            |       |          |
|----------------------------|-------|----------|
| Podium With Copy Stand     | 1,500 | 1,500    |
| Cables/Connectors          | 300   | 300      |
| Classroom Control Unit     |       | 5,000    |
|                            |       | -----    |
|                            |       | 29,853   |
| Anticipated Discount of 5% |       | 1,493    |
|                            |       | -----    |
| Total                      |       | \$28,360 |

OPTIONS:

|                                                                                                |       |
|------------------------------------------------------------------------------------------------|-------|
| Additional cost for upgrade to wireless microphone for teacher instead of lavalier microphone. | 1,144 |
| Video-Switcher remote panel                                                                    | 200   |
| White porcelain board                                                                          | 500   |
| Installation                                                                                   | 4,000 |
| Camera pan and tilt capability                                                                 |       |
| Graphics monitor                                                                               |       |
| Preview monitor for podium                                                                     |       |

101691